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Invertebrate fish food from dredged and undredged portions of North Twin Lake

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INVERTEBRATE FISH FOOD FROM DREDGED AND UNDREDGED PORTIONS OF NORTH TWIN LAKE

by

John Baxter Owen

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In Charge of Major Work

Signature was redacted for privacy.

Head of Major Department

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Dean of Graduate College

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I. INTRODUCTION

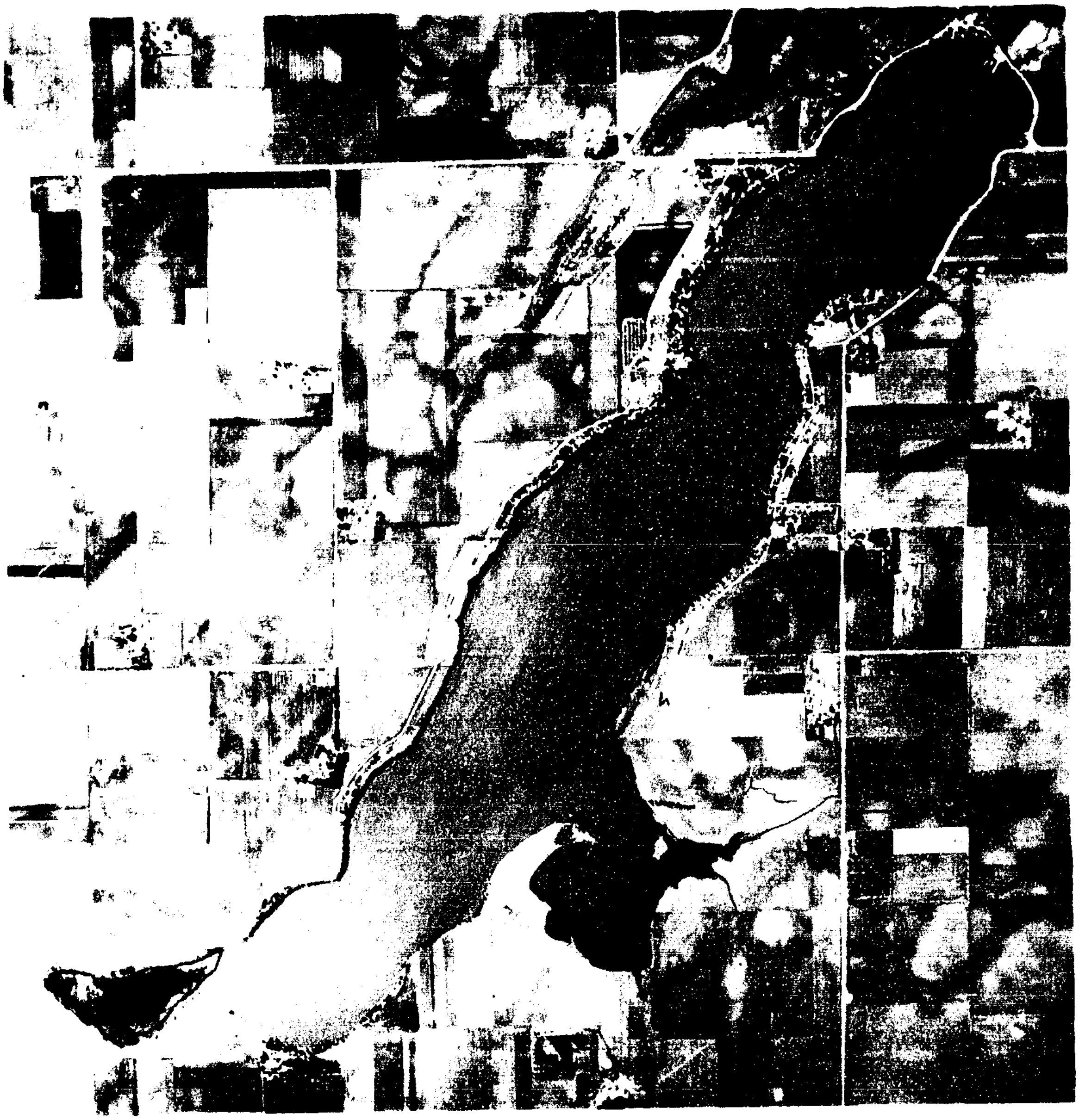
In the drought years of the 1930's, many of the shallow prairie lakes of recreational value in Iowa gave evidence of imminent extinction. Former good fishing lakes became choked with emergent vegetation and became subject to annual winter kill. As an emergency remedy for certain of the state's critically shallow lakes, the Iowa State Conservation Commission initiated a program of dredging to restore the water depths.

To date the policy of the Conservation Commission has been to consider dredging of Iowa's natural lakes as a last resort or emergency measure only. They have recognized that the long range ecological and limnological effects of such dredging operations are virtually unknown. They deferred adopting a general policy of dredging natural lakes until there was opportunity for the accumulation of scientific data and evaluation of dredging.

North Twin Lake (Fig. 1) in north central Calhoun County, was selected for this investigation of the ecological effects of dredging. Approximately 135 acres in the southern end of the lake were dredged to a depth of 14 to 18 feet in 1939 and 1940. The biological investigations were started in June, 1951. By this time it was expected that conditions in the undredged and dredged portions of the lake would be fairly stabilized. Since of the various aquatic communities, bottom fauna organisms can be expected to be most affected by the dredging, and since the bottom fauna are important fish foods, the present study has placed the principal emphasis on a comparison of the bottom fauna of dredged and undredged

Fig. 1. North Twin Lake, May 30, 1939.

(U. S. Department of Agriculture photograph)



portions of the lake. The problem can be separated into three parts: sampling aspects of estimating standing crops, estimation of production, and utilization of bottom fauna by fishes.

The estimation of the standing crop, or the amount of bottom fauna present in the lake at any one time, is complicated by the fact that the organisms are not evenly distributed and by the fact that the several species which are normally present may differ in the unevenness of their distribution. Furthermore, the standing crops in the dredged and undredged areas may not bear the same relationship to each other at various seasons of the year. To get average standing crops, the seasonal variation in abundance of various bottom organisms must be studied. Although many bottom fauna studies have been made, there is available very little information which may be used to determine the numbers and sizes of samples required for any specified degree of confidence. Some such estimates were made during the present study.

Even if the annual average standing crop of bottom fauna in the dredged and undredged areas of the lake were found to be the same, there might be important differences in the production of organisms in the two regions due to differences in the life cycles and rate of overturn. Some estimates of this rate of overturn are therefore desirable.

Finally, there may be differences in the utilization of the bottom fauna by fishes which are important in an evaluation of the biological effects of the dredging.

II. DESCRIPTION

North Twin Lake is approximately two and one-half miles long and about one quarter mile wide, with a surface area of 509 acres. The lake is situated in a level glacial plain which is devoid of striking features. North Twin Lake and neighboring South Twin Lake are glacial relicts. The lakes are situated in depressions in the ground moraine topography, left behind by the Mankato Lobe of the Fifth Wisconsin glaciation (Thwaites, 1935). The watershed of North Twin Lake is estimated to be 2,155 acres exclusive of the lake itself (Iowa State Planning Board, 1935). The watershed of the lake has been gradually enlarged by the installation of a network of drainage tiles, many of which drain into North Twin Lake. The various tile systems lead across shallow divides and drain former glacial "pot-holes." In the spring of 1954, unusually heavy rains "swamped" the tile systems in the countryside about the Twin Lakes. The pot-holes were temporarily flooded, and aerial photos give a hint of the original pot-hole topography before artificial drainage (Figs. 2 and 3).

The lake has low earthen banks, from two to five feet high for the most part, although one or two knolls ten to thirty feet high form part of the northeastern shore. Traces of an old "wall" of glacial boulders may be seen along the low western shore of the lake.

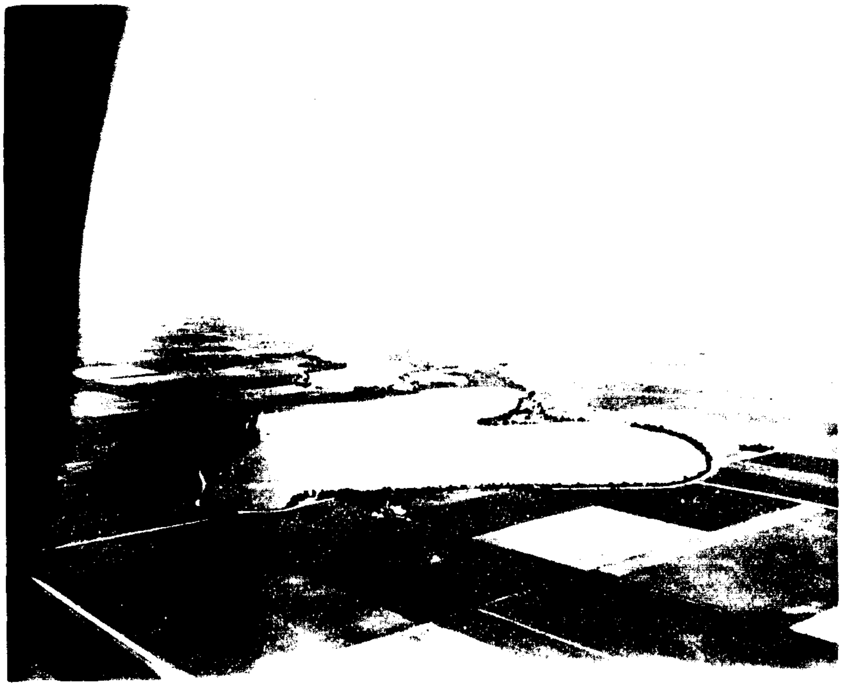
The lake in the years 1951 to 1955 was from four to seven feet deep in the northern end, and from 9 to 14 feet deep in the dredge cut in the southern end. The lake bottom is mud except for a narrow zone of sand around its shoreline.

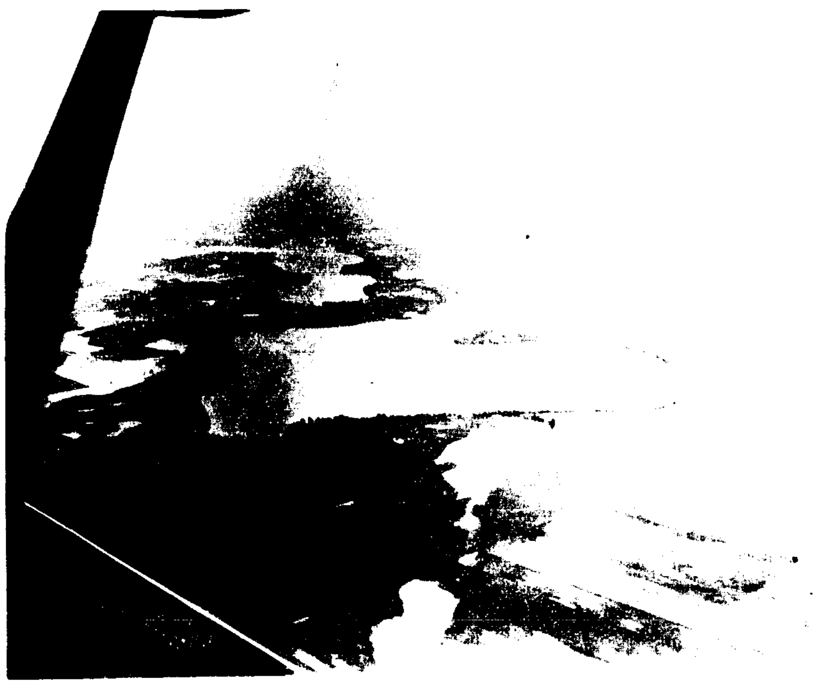
Fig. 2. North Twin Lake and South Twin Lake in foreground.

(Photo by C. E. Treman, Rockwell City Advocate)

Fig. 3. North Twin Lake and South Twin Lake. Flood in spring of 1954.

(Photo by C. E. Treman, Rockwell City Advocate)





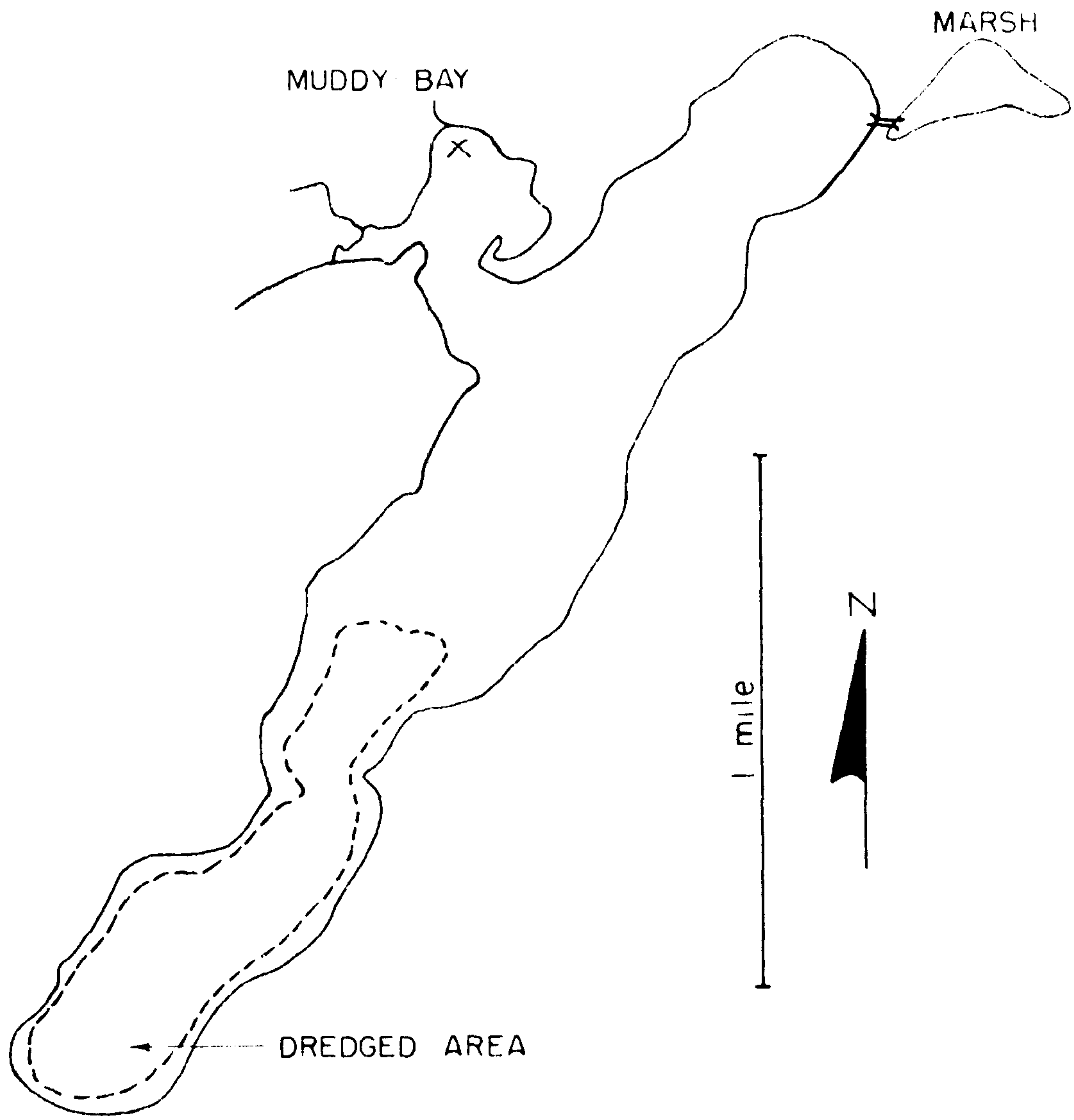
The survey of North Twin Lake by the Iowa State Planning Board in 1935 indicated that the original capacity of the lake basin was 72 percent filled with silt. At that time, the average depth of the water was 5.85 feet, and large areas were grown up in higher aquatic plants. The recreational value was endangered, and it was decided to restore the depth of the lake by dredging out the basin. In 1939 and 1940, an area of 135 acres in the southern end of the lake was dredged to a depth of 14 to 18 feet (Fig. 4).

North Twin Lake is so shallow, even after dredging, that the entire lake bottom falls within the littoral zone as defined by Carpenter (1928). The littoral bottom of North Twin Lake presents the two typical phases described by Carpenter. The first, or "erosion-littoral" region, is a rather narrow sandy beach which extends around the entire lake. The second region, or "quiet-littoral" zone comprises the remainder of the lake floor.

The sandy "erosion-littoral" zone extends from the foot of the cut banks to the water's edge and out into the lake for a variable distance. The sand of the "erosion-littoral" zone is washed free from the glacial till and kept clean by the continued scouring of wave action.

The "quiet-littoral" region within the lake is at depths protected from wave action. The "quiet-littoral" lake bottom has become covered with accumulated silt and sediments. A survey in 1954 indicated that 92 percent of the area of the lake bottom was covered with sediments, while only 8 percent of the bottom area was to be found in the fringe of erosion-littoral sands.

Fig. 4. North Twin Lake showing 135 acres dredged area.


MARSH
MUDDY BAY
1 mile
N
DREDGED AREA

The waters are highly eutrophic, reflecting the rich agricultural soil of its watershed and basin. Dissolved oxygen is well distributed from the surface waters down to near the bottom, attesting to effective circulation and aeration of the water mass. Apparently the lake is so shallow and exposed to the wind that it does not stratify thermally for any significantly continuous length of time during the summers.

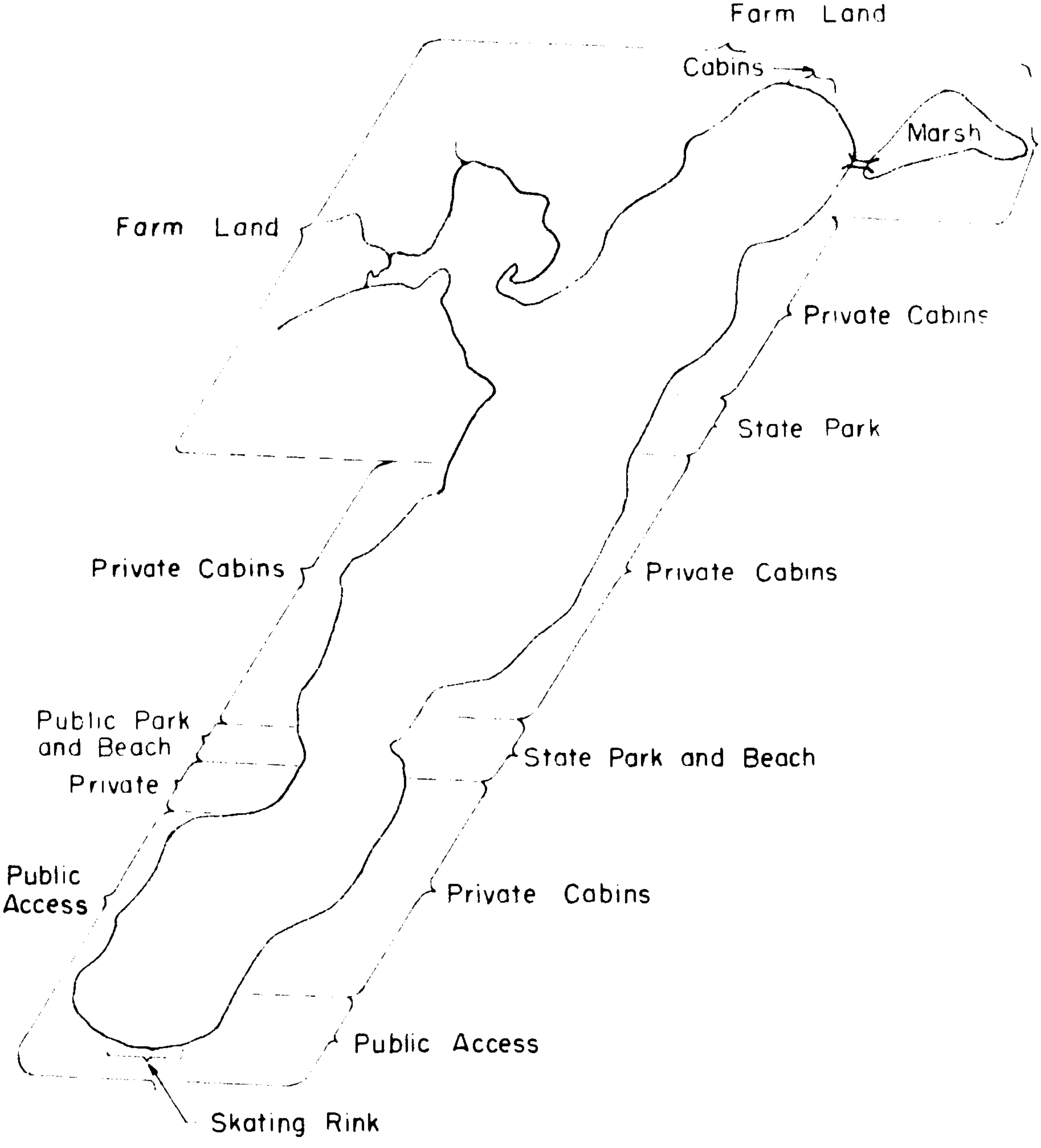
Turbidity of North Twin Lake water varies greatly. At times in some summers, the water supports a blue-green algal bloom. Temporary turbidity is also caused by storms which stir the bottom deposits. The shallow water is often noticeably stirred by heavy usage of motorboats on holidays and weekends.

Higher aquatic plants are virtually non-existent in North Twin Lake proper. Some cat-tails, *Typha* spp., arrowheads, *Sagittaria* spp., and bull-rushes, *Scirpus* spp. grow along the margins of Muddy Bay, however.

The lake has long been a valuable recreational site in that part of Iowa. It was reportedly a fabulous duck hunting area at about the turn of the century. A resort hotel was built on the lake shore at about that time, and hunting parties are said to have come to the Twin Lakes from as far away as Chicago.

As time went on, most of the swampy glacial depressions were artificially drained, and duck hunting about the Twin Lake has declined to a low ebb. However, the recreational value of this body of water has continued to grow, but in an entirely new form. North Twin Lake can now be termed a general aquatic recreational area. The lake is state-owned with a state park, swimming beach, picnic facilities, and numerous other state owned access points for launching boats (Fig. 5). The lake provides

Fig. 5. North Twin Lake. Land use around the shore.


Farm Land
Cabins
Marsh
Farm Land
Private Cabins
State Park
Private Cabins
Private Cabins
Public Park and Beach
Private
State Park and Beach
Public Access
Private Cabins
Public Access
Skating Rink

fair to good fishing for black bullhead, Ictalurus melas (Rafinesque), yellow bass, Roccus mississippiensis (Jordan and Eigenmann), yellow perch, Perca flavescens (Mitchill), walleye, Stizostedion vitreum vitreum (Mitchill), northern pike, Esox lucius Linnaeus, black crappie, Pomoxis nigromaculatus (LeSueur), and largemouth black bass, Micropterus salmoides salmoides (Lacepede).

In addition to the public facilities, there are between three and four hundred privately owned cabins around the lake. The cabins serve as summer residences or vacation spots for local residents, most of whom live within 25 miles of the lake. The cabins are along most of the eastern side of the lake and along the southwestern side. Many of the cabin owners have built retaining walls or riprapped their waterfront embankments to stabilize them.

III. BOTTOM FAUNA: SAMPLING METHODS

A. Collection of Samples

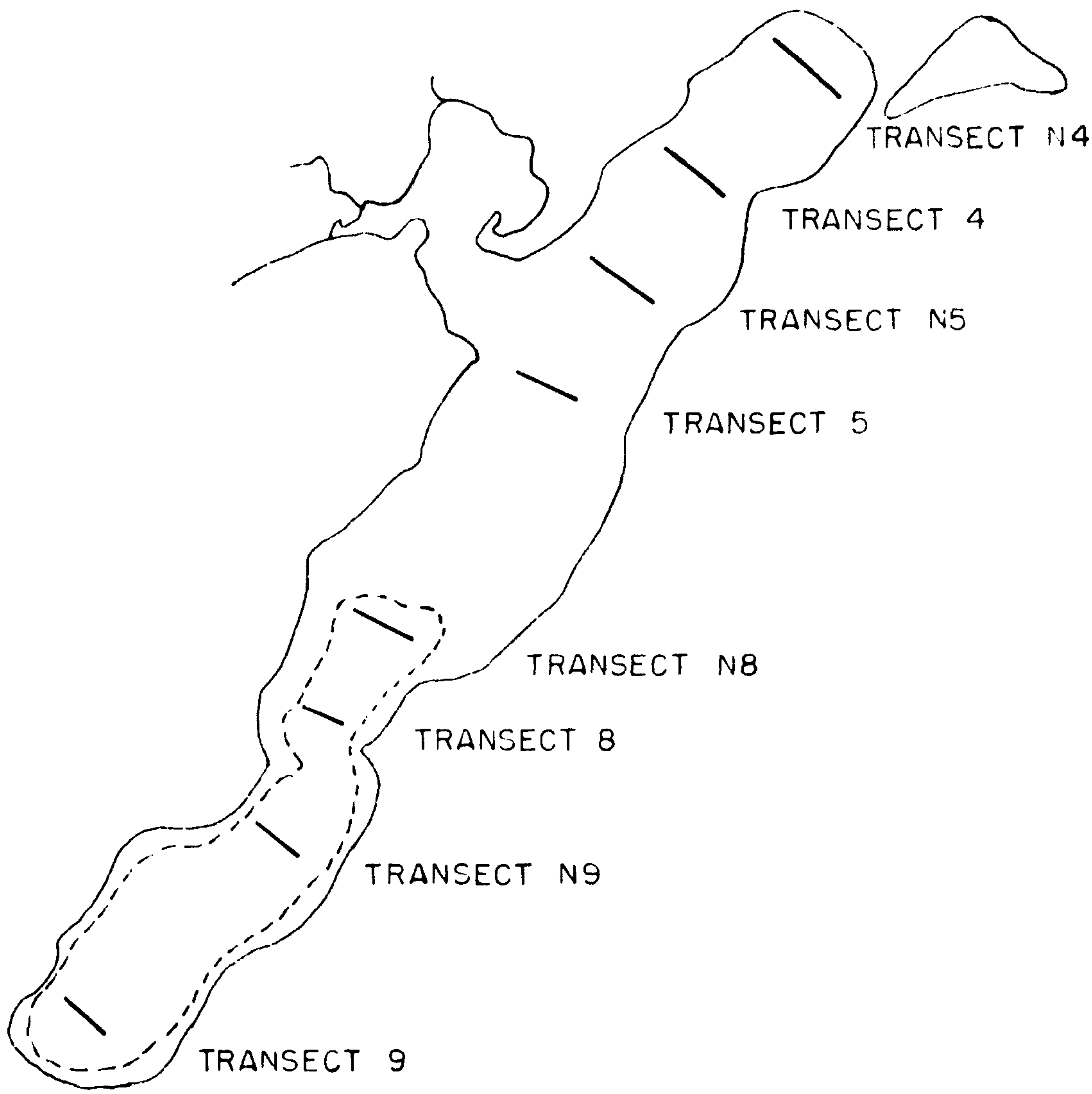
All bottom samples were taken with standard Ekman dredges. The 6-inch by 6-inch dredge was used throughout the study, but, in addition, one duplicate set of samples was taken with the 12-inch by 12-inch Ekman in 1954. As each sample was taken, the contents of the dredge were emptied into a floating box-sieve having a 40-mesh screen bottom. The mud was washed from the sample immediately and the gross residue put into a glass jar, labeled, and preserved with 10 percent formalin. In the laboratory later, the sample was washed to remove the formalin, spread out in water in a white tray, and the organisms were removed from the debris with forceps. The organisms from each Ekman dredge were then preserved in 70 percent alcohol in a separate vial.

B. Basic Sampling Design

At the start of the work in 1951, four sampling transects were set up. They were transects 4 and 5 in the undredged zone and 8 and 9 in the dredged zone (Fig. 6). Samples were taken at five locations along each transect spaced across the central portion of the quiet-littoral of the lake bottom. The five locations were about 175 feet apart and, for convenience, numbered 1 through 5 from east to west.

The procedure was to anchor the boat once at each location and take two individual Ekman samples. This was repeated until five pairs of separate Ekman samples were taken at each of the four transects. Forty

Fig. 6. North Twin Lake, bottom sampling transects. The transects added in 1954 have the prefix N.


TRANSECT N4
TRANSECT 4
TRANSECT N5
TRANSECT 5
TRANSECT N8
TRANSECT 8
TRANSECT N9
TRANSECT 9

such samples taken in about two days made a complete set from one period. Sampling was repeated at one to two month intervals during the summers and at longer intervals during the winters, from July 1951 to August 1954.

C. Comparison of Sampling Designs

To estimate the efficiency of various sampling designs compared to the basic plan described above, the complete set of data taken on March 20-21, 1954 were analyzed (Table 1). The comparisons were made on the basis of total volumes of organisms per Ekman dredge sample.

For a given sampling period, the variance of a sample mean is given by the following:

$$v(\overline{y}) = \frac{N-n}{N} \quad \frac{S_z^2}{n} + \frac{S_t^2}{nm} + \frac{S_s^2}{nmk} + \frac{S^2}{nmkl} \qquad (1)$$

where N = total number of zones

n = number of zones sampled

m = number of transects sampled in each zone

k = number of stations sampled in each transect

l = number of Ekman dredge samples taken at each station

and S_z^2 ; S_t^2 ; S_s^2 ; and S^2 are estimates of the contribution to the error term arising from differences among zone means, transect means, station means, and samples within pairs, respectively. It was assumed that the number of transects, stations, and Ekman dredge samples that could be taken or set up was very large, hence finite population correction factors have been ignored for all factors excepting zones, there being only two—dredged and undredged.

Table 1. Analysis of variance of total volumes of organisms per 36 square-inches, March 20-21, 1954, North Twin Lake, Iowa

Source of variation	Degrees of freedom	Sum of squares	Mean square	Expected mean square
Total	39	155,228.78		
Among zones	1	63,282.03	63,282.03	$s^2+2s_s^2+10s_t^2+20s_z^2$
Transects/ zones	2	24,749.65	12,374.82	$s^2+2s_s^2+10s_t^2$
Stations/ transects	16	46,011.60	2,875.72	$s^2+2s_s^2$
Samples/ stations	20	21,185.50	1,059.27	s^2

$s^2 = 1,059.27$; $s_s^2 = 908.22$; $s_t^2 = 949.91$

According to the basic sampling scheme, $n = 2$; $m = 2$; $k = 5$; $l = 2$; hence the variance of the sample mean for the March period in 1954 was as follows:

$$v(\bar{y}) = \frac{949.91}{(2)(2)} + \frac{908.22}{(2)(2)(5)} + \frac{1,059.27}{(2)(2)(5)(2)} = 309.37$$

Valid estimates of what the variance of the estimated volume of organisms per Ekman dredge is likely to be with alternative sampling fractions may be obtained simply by substituting various values for m, k, and l into (1) above. For one hypothetical scheme, the number of transects was doubled and the number of stations reduced from five to two with the following results:

$$v(\bar{y}) = \frac{949.91}{(2)(4)} + \frac{908.22}{(2)(4)(2)} + \frac{1,059.27}{(2)(4)(2)(2)} = 208.59$$

The efficiency of the alternative plan relative to the basic scheme was determined simply by taking the ratio of the two variances as follows:

$$\text{Relative efficiency} = \frac{309.37}{208.59} = 1.483 \text{ or } 148.3\%$$

Hence, in spite of the fact the alternative plan calls for fewer Ekman dredge samples, 32 as against 40, indications were that the alternative plan was approximately 48 percent more efficient than the basic plan. Sampling according to the alternate scheme was actually carried out in the March period with the following results (data from Table 2):

$$v(\bar{y}) = \frac{441.15}{(2)(4)} + \frac{1,266.31}{(2)(4)(2)} + \frac{1,234.87}{(2)(4)(2)(2)} = 172.86$$

Table 2. Analysis of variance of total volumes of organisms per Ekman sample, March 20-21, 1954, North Twin Lake, Iowa

Source of variation	Degrees of freedom	Sum of squares	Mean square	Expected mean square
Among zones	1	60,726.88	60,726.13	$S^2+2S_s^2+4S_t^2+16S_z^2$
Transects/ zones	6	33,192.13	5,532.12	$S^2+2S_s^2+4S_t^2$
Stations/ transects	8	30,140.00	3,736.50	$S^2+2S_s^2$
Samples/ stations	16	19,758.00	1,234.87	S^2
Total	31			

S^2 - 1,234.87 ; S_s^2 - 1,266.31 ; S_t^2 - 441.15

For reasons that will be developed later, it may be desirable to take but one Ekman per station. If the number of transects is increased to 8 per zone and number of stations maintained at two per transect, the total number of Ekman samples will still be 32, but there will be further gains in precision. The estimated variance of the sample mean with the latter set-up is 112.85.

The basic plan, of course, was maintained throughout the study. At North Twin Lake the evaluation of the basic plan was seriously delayed because of the length of time needed for picking the organisms from the preserved samples. The lake bottom contains amounts of plant fibers which interfere with rapid processing of the samples.

IV. BOTTOM FAUNA: NUMBERS AND DISTRIBUTION

A. Major Groups of Organisms

It was found that the bottom fauna of North Twin Lake could conveniently be separated into four groups:

1. Larvae and pupae of Chaoborus punctipennis (Say),
2. Larvae and pupae of various species of Chironomidae,
3. Oligochaeta,
4. Other organisms.

The category "other organisms" included the bottom fauna which were so few in numbers, so spotty in distribution, and so insignificant in bulk that no estimate of their numbers, weights, or values as fish-food could be made.

Oligochaeta were present in significant numbers in the bottom fauna but were apparently of no significance as food for any of the species of fish in North Twin Lake. Examination of the contents of 2,740 stomachs of fish from North Twin Lake in 1953 and 1954 revealed no Oligochaeta (Kutkuhn, 1954). Neill (1938) found Oligochaeta, because of their burrowing habits, to be completely secure from predation by brown trout in streams. Oligochaeta will not be considered further here.

Attention was centered upon Chaoborus and the various Chironomidae, which together comprised the bulk of the bottom fauna and also were found to be the two most important items of fish food from the bottom fauna (Kutkuhn, 1954). Particular attention was paid to Chaoborus, as the key species in the comparison of the fauna of the dredged and undredged areas of the quiet-littoral zone of the lake. Chaoborus alone of all the species of the quiet-littoral zone seemed clearly to be characteristic of one area of the lake, the dredged area. Moreover, this single interesting species at times loomed large in numbers and weights per unit area of lake bottom compared to the combined Chironomidae (Fig. 7). The Chaoborus and Chironomid larvae from each sample were counted and these counts are summarized in the appendix.

Aquatic invertebrates of North Twin Lake were identified by use of the following keys and manuals:

Diptera: Johannsen (1937a, 1937b)

Ephemeroptera: Burks (1953)

Trichoptera: Ross (1944)

Pennak (1953) was consulted for identification of several groups of invertebrates. Supplemental information on distribution and biology of Chironomidae was obtained from Townes (1945). The terminology of Bailey (1956) was followed in identification of the fishes in North Twin Lake.

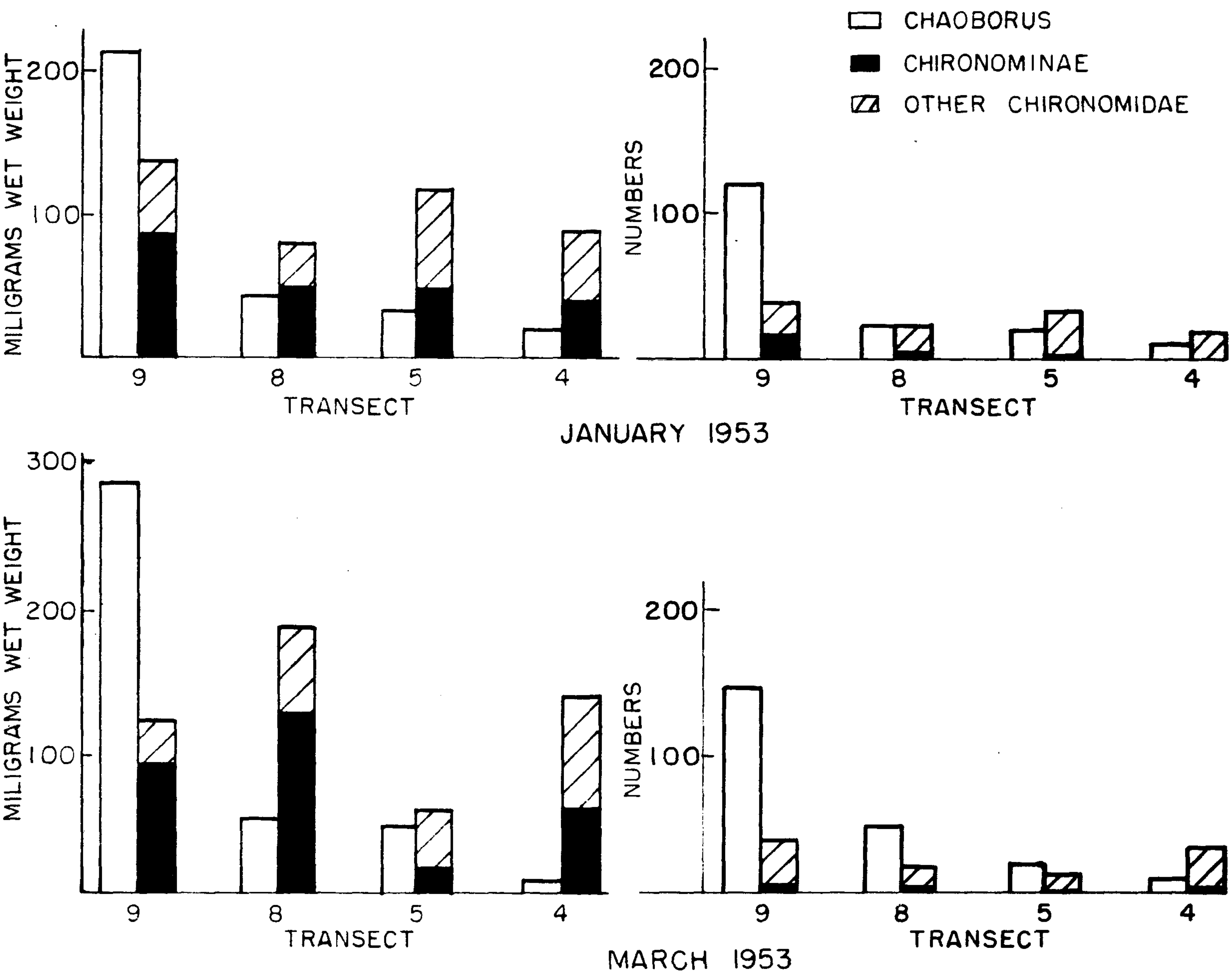
B. Phantom Midge, Chaoborus punctipennis (Say)

1. Length class segregation in samples

The length of each Chaoborus larva was measured in hopes that the generations of Chaoborus could be identified and that the numbers could be converted to volumes or wet weights for computing standing crops. It was also thought that the sizes of Chaoborus in different samples collected in one sampling period might be similar enough that some general factor could be used for converting numbers to volumes or wet weights.

A check of the set of samples with the largest number of Chaoborus

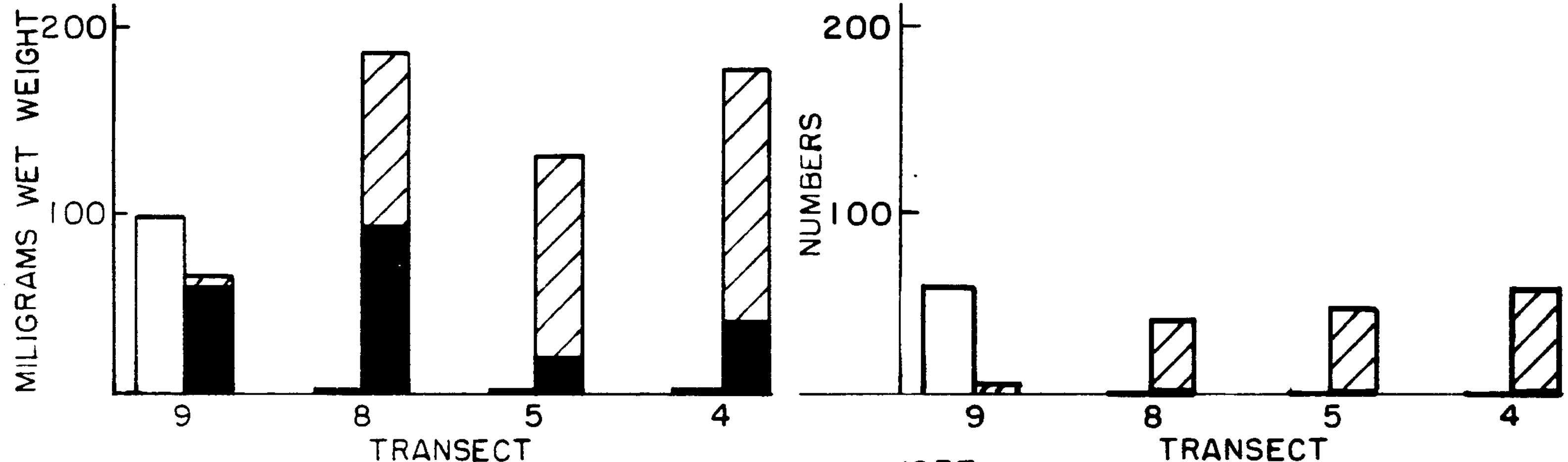
Fig. 7. Number of larvae per square foot and milligrams of wet weight per square foot of *Chaoborus punctipennis* at all transects in North Twin Lake in 1953.


CHAOBORUS
CHIRONOMINAE
OTHER CHIRONOMIDAE
MILIGRAMS WET WEIGHT
NUMBERS
300
200
100
9
8
5
4
TRANSECT
JANUARY 1953
MARCH 1953

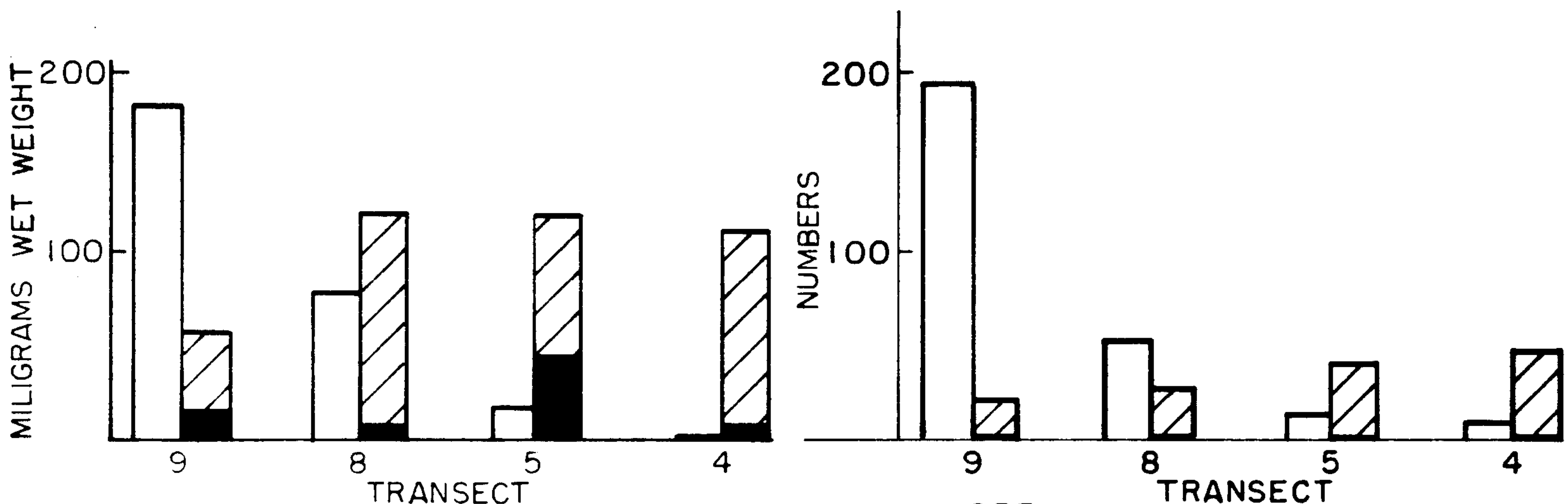
9 8 5 4
TRANSECT

9 8 5 4
TRANSECT

MARCH 1953



JULY 1953



AUGUST 1953

(Table 3) revealed some small differences in the size distributions in the various samples. An analysis of variance (Table 4) showed no discernible location effect. The larvae at the five locations on the transect seem to be approximately the same lengths. Surprisingly, however, there was a highly significant difference between the lengths of the Chaoborus in the two samples at each location. Similar analyses of variance for five more transects were tried to see whether the difference between samples occurred frequently (Tables 5 to 9). In three of the five, the differences between samples at the stations were statistically significant.

It is felt that the sampling technique may be faulty or inadequate, and did not capture an equally representative sample of the larvae of all lengths on each of the two dredge hauls at the same location. The smaller larvae, below three to four millimeters in length, are free-swimming, while the larger ones tend to be true benthic organisms (Juday, 1921). It is possible that the first dredge sample at a new location may capture a proportion of small larvae as well as the larger benthic forms, but the operation of the dredge during the first haul could frighten away the smaller larvae, so that not as high a proportion of them would be captured by the second haul. No good quantitative sampling instrument is known for capturing organisms such as Chaoborus, which are in part free swimming and in part benthic.

It seems likely that the number of Chaoborus larvae in North Twin Lake is underestimated because of bias from the samples being taken in pairs. The bias could perhaps be reduced by taking only one sample at each location.

Table 3. Frequency of occurrence of Chaoborus larvae of various lengths, and estimates of mean lengths of larvae, March 21, 1954

Sample number	Total number of Chaoborus larvae	Number at each millimeter of length 4	5	6	7	8	9	10	Mean length of larvae in millimeters	
9-1A	40		1	1	8	29	1		7.70	
9-1B	56				9	38	9		8.00	7.87
9-2A	68	1		3	7	53	4		7.81	
9-2B	42				7	32	3		7.90	7.84
9-3A	43				5	34	4		7.98	
9-3B	59				4	53	2		7.97	7.97
9-4A	152		1	5	6	51	82	7	8.92	
9-4B	117				13	94	10		7.97	8.27
9-5A	49		3	2	5	34	5		7.73	
9-5B	93		1		3	80	9		8.03	7.93
Total	719	1	6	11	67	498	129	7		

Table 4. Analysis of variance of lengths of Chaoborus punctipennis larvae at transect 9, March 21, 1954

Source of variation	d.f.	Sums of squares	Mean square	
Among locations	4	28.8522	5.963	F 1.248
Among samples/location	5	23.8819	4.776	F 11.726**
Among individual larvae/sample	709	288.8417	0.4073	
	718	336.5758		

** = Significant at .01 level

Table 5. Analysis of variance of lengths of *Chaoborus punctipennis* larvae at transect 8, January 26, 1953

Source of variation	d.f.	Sums of squares	Mean square		
Among locations	4	3.4365	0.8591	F	9.72*
Among samples/location	5	0.4418	0.08836	F	0.2517
Among individual larvae/sample	44	15.4551	0.3512		
	53	19.3334			

* = Significant at .05 level

Table 6. Analysis of variance of lengths of *Chaoborus punctipennis* larvae at transect 9, January 25, 1953

Source of variation	d.f.	Sums of squares	Mean square		
Among locations	4	1.0706	0.2676	F	0.2329
Among samples/location	5	5.744	1.1488	F	2.673*
Among individual larvae/sample	202	86.8224	0.4298		
	301	93.6474			

* = Significant at .05 level

Table 7. Analysis of variance of lengths of *Chaoborus punctipennis* larvae at transect 8, August 19, 1953

Source of variation	d.f.	Sums of squares	Mean squares		
Among locations	4	29.6451	7.4113	F	0.7917
Among samples/location	5	46.8057	9.3611	F	6.552**
Among individual larvae/sample	136	194.2958	1.4286		
	145	270.7466			

** = Significant at .01 level

Table 8. Analysis of variance of lengths of Chaoborus punctipennis larvae at transect 9, August 28, 1953

Source of variation	d.f.	Sums of squares	Mean squares	
Among locations	4	31.1506	7.7876	F 0.779
Among samples/location	5	49.9823	9.99	F 6.508**
Among individual larvae/sample	497	794.4071	1.535	
	506	875.5400		

** = Significant at .01 level

Table 9. Analysis of variance of lengths of Chaoborus punctipennis larvae at transect 8, March 21, 1954

Source of variation	d.f.	Sums of squares	Mean squares	
Among locations	4	2.0795	0.5199	F 1.178
Among samples/location	5	2.2066	0.4413	F 1.351
Among individual larvae/sample	248	81.0046	0.3266	
	257	85.2907		

2. Distribution of Chaoborus punctipennis larvae in North Twin Lake during 1953

The 1953 data were selected for further analysis of the seasonal and spatial distribution of Chaoborus larvae (Fig. 7).

The data indicate beyond doubt that the phantom larvae were much more numerous in the dredged zone of North Twin Lake than in the undredged zone and were particularly concentrated at transect 9, in the deepest area. A statistical analysis to confirm the preponderance of Chaoborus in the dredged zone seemed superfluous; however, it was felt that an analysis of variance of the distribution of larvae by samples, locations, transects, zones, and seasons through an entire year might yield valuable information on seasonal effects and perhaps interactions that otherwise might be hidden (Table 10).

Table 10. Analysis of variance of the distribution of individual larvae of Chaoborus punctipennis (Say) in the bottom of North Twin Lake during the year 1953

Source of variation	d.f.	Sums of squares	Mean squares	
Sampling periods	3	4,172.1188	1,390.7062	F 28.71**
Locations	4	268.0250	67.0062	F 1.383
Zones	1	11,306.4063	11,306.4063	F 14.62*
Transects/zones	2	14,219.8625	7,109.9312	
Periods x locations	12	581.2250	48.4354	F 1.151
Periods x zones	3	2,334.4687	778.1562	F 20.86*
Locations x zones	4	130.6249	32.6562	F .8755
Periods x locations x zones	12	447.6251	37.3021	F .8861
Periods x transects/zone	6	1,250.387	208.3978	F 5.411*
Locations x transects/zone	8	720.200	90.025	F 2.338
Periods x locations x transects/zones	24	924.300	38.5125	F .9149
Error	80	3,367.500	42.0937	
	159	39,722.7438		

* = Significant at .05 level

** = Significant at .01 level

The highly significant difference found between sampling periods is attributed to the normal seasonal fluctuation in numbers. Chaoborus larvae were abundant in January and in March. Of the four sampling periods in 1953, July showed the lowest numbers of Chaoborus in North Twin Lake, probably due to emergence of adults prior to this time. In August Chaoborus larvae were much more abundant, but the average size and the volume were low. Juday (1921) found large numbers of the larvae of Chaoborus punctipennis in Lake Mendota beginning in the fall and increasing into winter to a peak in January or as late as March. Numbers of larvae declined sharply in May and June with the lowest number in August. The decline in larval numbers during the summer is caused by emergence of adults and probably in part by an increased rate of predation by fish. Lindquist and Deonier (1942a) found the heaviest emergence of Chaoborus asticopus in early August, and also the heaviest predation by fish at that time.

A similar seasonal cycle of Chaoborus larvae is shown by the collections each year at North Twin Lake, although there were some differences from year to year in overall numbers of larvae.

The significant difference between the number of larvae between zones appears to depend principally upon transect 9 in the extreme southern end of the lake. Transect 8, also in the dredged zone, but at a shallower depth, seems to support only intermediate numbers of Chaoborus larvae. At times in the summer, the number of larvae at transect 8 does not exceed that of the undredged zone transects.

Transect 8 seems to be responsible for the significant interaction between periods and zones and probably also that between periods and transects per zone. The number of larvae on transect 8 during the winter periods seems to be high, consistent with the numbers of larvae at transect 9 in the dredged zone. During periods in the summer, the numbers of larvae on transect 8 is as low as it usually is in transects 4 and 5 of the undredged area.

This interesting interaction apparently indicates that in the intermediate depths of transect 8, the number of larvae is affected by some outside environmental effect during the summer more than it is during the winter. Possibly the bottom temperature for a time during the summer may be somewhat higher at transect 8 and in the undredged zone transects than it is at transect 9. Development would possibly be more rapid and emergence earlier at transect 8 than at transect 9. Another possible cause of the interaction may be the anaerobic conditions that have been observed in the lake bottom deposits of the deepest parts of the dredged zone in the summer. *Chaoborus* larvae are facultative anaerobes and would have an exceptional degree of protection in the bottom ooze of transect 9 at that time.

C. Chironomidae

Examination of the 1953 data (Fig. 7) and of the 1951, 1952, and 1954 data (Appendix) reveals no consistent trend or concentration of Chironomid larvae either by numbers or weights in any area of the lake bottom. The variability from transect to transect and from sampling period to sampling period is such that interpretation of the data is difficult. Chironomids apparently were more abundant in 1951 than in the other years, but statistical analysis is deferred until the various species of larvae can be identified and treated separately.

It can be seen that the large larvae of the Chironominae, while present in relatively small numbers, may provide a disproportionately large share of the total wet weights of the Chironomidae. The larger larvae of the Chironominae are probably not sampled with the degree of accuracy obtained with the smaller and much more numerous other Chironomidae.

Lindeman (1942) states that he found "great fluctuations and species-substitutions . . . in the Cedar Bog Lake population of Chironomus plumosus and Chironomus decorus" (Chironominae). These same two species are presumed present at North Twin Lake, and fluctuations in the abundance of these large "blood-worm" larvae may dominate the total Chironomid bottom fauna production at North Twin Lake.

Lindeman felt that in Cedar Bog Lake, the fluctuation in weather conditions from year to year was largely responsible for the fluctuation in abundance of Chironomus plumosus and Chironomus decorus. Fishes were rare in Cedar Bog Lake and probably played a minor role as predators upon the Chironomidae in that lake. On the other hand, North Twin Lake supports a vigorous population of mixed game, pan, and forage fishes, nearly all of which prey on Chironomid larvae at least some time in their life (Kutkuhn, 1954).

Ball (1948) calculated that a fish population of bluegills, Lepomis macrochirus Rafinesque, and largemouth bass, Micropterus salmoides salmoides (Lacepede), in a small lake in Michigan consumed 1.1 percent of the standing crop of bottom fauna per day in the summer time. Later, the fish population was removed by poisoning, and in eight months the bottom fauna population reached a peak of nearly twice that ever reached in the three previous years (Ball and Hayne, 1952). Ball (1948) also found selectivity of food organisms by bluegills. Midge larvae were taken in greater proportion than their relative abundance in the lake. Caddis fly larvae, on the other hand, were taken as food proportionately less than their relative abundance in the lake. In two similar ponds, Hayne and Ball (1956) demonstrated the pronounced effect which fish may have on bottom fauna by measuring bottom fauna production with and without fish present.

The pressure from fish predation upon Chironomidae in North Twin Lake is believed to be variable from year to year. The various species of fish in North Twin Lake have extremes of spawning success in different years, and as a consequence, the proportion of various age classes of all species of fish is probably never quite the same in North Twin Lake.

The larvae of Chironomidae follow a seasonal cycle of abundance with peak numbers in the late winter and spring and a decline in numbers in the summer similar to that of *Chaoborus*. The fluctuation of numbers of the combined species of Chironomidae is not so well marked as in *Chaoborus*, however, probably because of differences in the life histories and emergence periods of the various species.

V. BOTTOM FAUNA: STANDING CROP

Clarke (1954) defines the standing crop as the abundance of organisms existing in the area at the time of observation. He says it may be expressed as numbers of individuals or as biomass or in other suitable terms.

A search was made for the most meaningful unit for expressing standard crop in terms of potential food for fish in North Twin Lake. It was decided to calculate the standing crop of *Chaoborus punctipennis* and Chironomidae in the various areas of the lake in wet weights and in weights of crude protein per unit area.

Wet weights were determined by an adaptation of the displacement methods of Ball (1948) and Hunt (1953). Ball found that soft-bodied invertebrates of representative groups in the bottom fauna had a density of 0.97. Hunt found *Hexagenia limbata* to have a density of 0.98. Both workers considered the density so near unity that they determined the weights of the organisms as being equivalent to the volumetric displacement.

Volumes of organisms were obtained by immersing them in a calibrated centrifuge tube. The tube was held in a frame which held the tube level at all times and also had an eyepiece to insure that the eye was at the same relative position each time the scale was read. It was found by tests with a buret that while the centrifuge tubes were accurate, they could not be held in the hand and read with reasonable accuracy.

The volume of *Chaoborus* larvae of individual samples could not be obtained by direct measurement because of the small sizes of the organisms.

The volume of a large number of Chaoborus of each millimeter size group was determined, and a factor obtained for the volume of one larva of the respective size group (Table 11).

Table 11. Chaoborus punctipennis larvae. Conversion factors, length to volume.

Length (millimeters)	Volume (milliliters)
4	.00020
5	.00039
6	.00068
7	.00108
8	.00161
9	.00229
10	.00316

All Chaoborus larvae of each sample were measured to the nearest millimeter, the appropriate factors applied, and the total volume of the organisms for the sample calculated.

The total volume of Chironomidae was measurable by direct displacement in some cases. In other samples, the volume of Chironomidae was too small for accurate readings. In samples with small amounts of Chironomidae, the organisms of a complete transect were segregated into size groups, the volumes of each size group measured, and the volumes of organisms in each sample allocated in proportion to the number of larvae of the size-group present in the sample.

The crude protein content (Table 12) of Chaoborus punctipennis (as Corethra punctipennis) and Chironomus tentans was determined by Juday (1921).

Table 12. Analysis of the larvae of Chaoborus punctipennis (as Corethra punctipennis) stated in percentage of the dry weight. (From Juday, 1921)

	Nitrogen	Crude protein (N X 6.25)
Corethra	10.74	67.12
Chironomus tentans	7.36	46.00

Juday also worked out the relation of wet weight to dry weight of Chaoborus punctipennis larvae at the various months of the year (Table 13).

Table 13. Average weight of a single individual of Chaoborus punctipennis (from Juday, 1921).

Month	Live wet weight (milligrams)	Dry weight (milligrams)	Percentage water
February	3.06	0.250	91.72
May	3.30	0.264	92.12
June	3.15	0.311	89.13
September	2.57	0.182	92.93
October	2.83	0.264	90.66
November	3.20	0.285	91.03

From these data of Juday, factors were derived for converting milligrams of wet weight to milligrams of crude protein (Table 14).

The conversion factor for converting wet weights of Chironomidae to milligrams of crude protein was also taken from Juday (1921). His analyses were based on the larvae of Chironomus tentans. Juday's factor was in terms of dry weight of Chironomus tentans to dry weight of crude protein. It was necessary to calculate a new factor to convert North

Table 14. Conversion factors for converting wet weight of Chaoborus punctipennis to crude protein.

Month	Conversion factor
January - March	0.05483
April - May	0.05369
June	0.06624
July	0.06000*
August	0.05376*
September	0.04752
October	0.06255
November - December	0.05980

* Obtained by interpolation.

Twin Lake larvae from wet weight to dry weight. This was done by taking all the Chironomidae of all species from four transects, measuring their volume, drying them for 24 hours at 80°C, and weighing them. It was found that one milligram wet weight was equivalent to 0.05111 milligrams of crude protein. It was assumed that the protein content and water content of Chironomidae of North Twin Lake were equal to Chironomus tentans.

It is indicated that the combined bottom fauna per acre is more abundant in the dredged area of North Twin Lake than in the undredged area through all seasons of the year (Tables 15 and 16). Chaoborus is especially more numerous in the dredged zone, being approximately four times as abundant there during all seasons.

The Chironomidae are present in substantial numbers in both the dredged and undredged areas at all times. Fluctuations in abundance of Chironomidae are not as marked as in the case of Chaoborus. From September through the following June, Chironomidae have a greater bulk in the dredged zone than

Table 15. Standing crops per acre in dredged and undredged areas of North Twin Lake.

Collection period	Wet weights in pounds per acre: Dredged area: Chaoborus	Dredged area: Chironomid	Dredged area: Total	Undredged area: Chaoborus	Undredged area: Chironomid	Undredged area: Total	Crude protein in pounds per acre: Dredged area	Crude protein in pounds per acre: Undredged area
Jan. 1952	21.9	32.0	53.9	8.64	12.7	21.3	2.93	1.15
Jan. 1953	12.3	10.5	22.8	2.88	9.99	12.9	1.21	.667
Mar. 1953	16.6	15.0	31.6	3.84	9.79	13.6	1.68	.707
Mar. 1954	25.4	17.1	42.5	4.41	10.4	14.8	2.26	.770
April 1952	13.2	13.6	26.8	3.55	10.8	14.4	1.41	.745
May 1952	7.30	17.4	24.7	2.20	19.4	21.6	1.28	1.11
June 1952	4.23	52.2	56.4	1.15	27.8	29.0	3.06	1.49
July 1951	4.23	41.0	45.2	1.34	45.6	46.9	2.34	2.42
July 1952	2.60	10.3	12.9	.961	3.0	4.0	.685	.215
July 1953	4.81	12.2	17.0	.038	15.0	15.0	.913	.683
July-Aug. 1954*	11.7	6.15	17.9	3.06	5.67	8.7	1.00	.473
July-Aug. 1954**	4.81	9.50	14.3	3.84	7.50	11.3	.744	.620
Aug. 1951	4.52	6.72	11.2	.575	20.6	21.2	.587	1.09
Aug. 1953	12.9	9.01	21.9	1.54	11.9	13.4	1.15	.691
Sept. 1952	19.0	.864	19.9	3.66	1.82	5.5	.948	.266
Oct. 1951	27.8	21.1	48.9	5.67	7.87	13.5	2.94	.758
Nov. 1951	15.4	16.2	31.6	9.02	10.8	19.8	1.74	1.10
Nov. 1952	20.0	7.30	27.3	4.70	2.11	6.8	1.58	.392

* July-August 1954 samples taken over an extended period of time, hence not comparable with samples taken at other periods.

** July-August 1954 data from 12 inch x 12 inch Ekman samples, not comparable with samples taken at other periods.

Table 16. Standing crop of bottom fauna in pounds per acre at North Twin Lake for all sampling periods, 1951 through 1954.

Months	Number of sampling periods	Wet weights						Crude protein	
		Dredged			Undredged				
		Chaoborus	Chironomidae	Total	Chaoborus	Chironomidae	Total	Dredged	Undredged
December-March	4	19.1	18.6	37.7	4.9	10.7	15.6	2.02	0.82
April-June	3	8.2	27.7	35.9	2.3	19.3	21.6	1.92	1.11
July-August	6	6.8	14.2	21.0	1.3	17.0	18.3	1.11	0.93
September-November	4	20.5	11.4	31.9	5.8	5.7	11.5	1.80	0.63
Average annual standing crop*		14.7	18.4	33.1	3.9	12.7	16.6	1.89	0.70

* Average standing crop determined by weighting the seasonal averages by the number of months in the designated season.

in the undredged zone. Only during the months of July and August do the Chironomidae of the undredged zone exceed the Chironomidae of the dredged zone in bulk. Even in July and August, the total standing crop remains higher in the dredged zone because of the greater amounts of Chaoborus present in the deep area.

It may be that the Chironomid larvae of the shallow undredged portion of the lake have a relative advantage in the months of July and August that they do not have in other months of the year. It would seem possible that warmer bottom temperatures and better aeration in the undredged area during the summer might favor more rapid development and a greater standing crop.

VI. BOTTOM FAUNA: NUMBER OF GENERATIONS

A. Introduction

It has been shown that the average annual standing crop of bottom fauna is greater in the dredged than the undredged portions of North Twin Lake. From the standpoint of the production of fish food in the two portions, there is also the question of the rate of overturn of the population - the number of generations. A more rapid rate of overturn might mean a greater production with a smaller standing crop.

B. Chaoborus punctipennis (Say)

1. Review of life history

The life cycle of Chaoborus punctipennis (Say) in the north central United States has been studied by Muttkowski (1918), Juday (1921), and Eggleton (1931, 1934, 1935). In California, the "Clear Lake gnat", Chaoborus asticopus (Dyar and Shannon), has been studied exhaustively by Lindquist and Deonier (1942a, 1942b, 1943) and Deonier (1943). The European species of Chaoborus have been investigated by several leading limnologists including Akehurst (1922), Alm (1922, 1923), Berg (1937), Frankenberg (1915), and Peus (1934).

The few species in the genus Chaoborus are quite alike in their morphology, and moreover, under comparable conditions, the different species have amazingly similar habits and life histories. The consistent similarity of the life histories in the several species in this small genus has aided greatly in piecing together from scattered investigations a rather comprehensive knowledge of the life history.

The basic life history of the group is simple. The eggs are laid in the water; they hatch quickly into free-swimming aquatic larvae. Pupation occurs from a few weeks to several months later. After about three days as pupae, the adults emerge. There may be several complete generations during the summer. The numbers of successive swarms of emergent adults are dependent upon length of summer, water and bottom ooze temperatures, and weather conditions. Those larvae which are hatched in the fall, too late for successful pupation and emergence that season, spend the winter as larvae and pupate the following spring.

Adult female *Chaoborus punctipennis* lay their eggs on the water surface near shore (Juday, 1921). Lindquist and Deonier (1943) found that the "Clear Lake gnat," *Chaoborus asticopus*, which also lays its eggs near shore on calm warm nights is dependent upon favorable weather for successful oviposition. Favorable weather at the right time was followed by a great increase in the number of larvae in the lake. Storms prevented oviposition by adults.

The eggs of *Chaoborus punctipennis* sink and at 21 to 24°C hatch within 48 hours (Muttkowski, 1918). Eggs may develop under anaerobic conditions as well as aerobic conditions. *Chaoborus* larvae grow rapidly. The summer broods of *Chaoborus punctipennis* spend only six to seven weeks in the larval stages (Muttkowski, 1918).

Throughout their larval life, *Chaoborus* larvae exhibit a peculiar vertical diurnal migration. The larvae swim actively to the surface waters during the hours of darkness and retreat to the dark depths during the daylight hours. Not all the larvae make the trip each night, however. Juday (1921) found in Lake Mendota, Wisconsin, that from one-half to as many as two-thirds of the normal numbers of larvae remained in the bottom during the night. None of the larvae remained in the surface waters during the day, however. Juday found this upward movement in Lake Mendota to be at the rate of 23.5 meters per hour, and their downward speed to be even faster.

All sizes of larvae make the upward migration and retreat during the day to the depths. However, the smallest, young larvae have significantly different habits from the older, well-developed larvae with regard to the depths in which they spend the daylight hours. The young larvae of Chaoborus punctipennis from the time of hatching until they are 3 millimeters in length or a little larger are limnetic. In large lakes, they spend the daylight hours in the vicinity of the thermoclime or just below the thermoclime. In small lakes they are free swimming near the bottom during the day. The larger larvae of the same species burrow into the bottom mud during the daylight hours. Cole (1953) found from core samples that Chaoborus punctipennis larvae were well distributed from one to ten centimeters deep in the profundal mud of Douglas Lake, Michigan.

Chaoborus larvae are found in the greatest numbers in the bottom fauna of deeper lakes, particularly those which stratify and become oxygen deficient in the hypolimnion. Oxygen depletion or exhaustion tends to suppress or eliminate all other invertebrate competitors in such lakes. Since Chaoborus larvae are facultative anaerobes, they tend to take over the oxygen-free depressions of deep lakes in prodigious numbers. Juday

(1921) found over 30,000 larvae of Chaoborus punctipennis per square meter in Lake Mendota bottom samples. Juday also found in Lake Mendota and nearby lakes that the deepest depressions invariably had the densest Chaoborus larval populations. A few Chaoborus were found in the shallower water of Lake Mendota up to around ten meters.

In adjacent Lake Waubesa, which is only 11 meters deep at its greatest depth, Juday found the Chaoborus population to be low, but at times about as great as it was at ten meters in Lake Mendota. The deepest waters of Lake Mendota had from 40 to 100 times as many Chaoborus larvae as the deepest waters of Lake Waubesa.

Berg (1937) in Denmark worked on the ecology and depth distribution of Chaoborus flavicornis in lakes of different sizes and depths. He found the larvae to be present in Sorte Dam, barely one meter deep, with a bottom covered with leaves and debris. They were also common in Fredericksberg Castle Lake, three meters deep; but in Esrom Lake, 20 meters deep, they were common only in the depths from 18 to 20 meters deep. They were rare from 18 meters up to 15 meters deep and were not found in shallower water in this lake. Berg cited Alm (1922), who found the larvae of the same species in roadside ditches and was at a loss to explain why they could not be found at comparable depths in larger bodies of water. Berg believed that the apparent discrepancy in the distribution of Chaoborus larvae was due to the quality of the bottom, particularly the softness of the muds.

It is apparent from the foregoing that depth distribution of the two species of Chaoborus larvae as bottom dwellers is not due to depth of water alone. The following summary compares the information we have on Chaoborus punctipennis in Iowa waters with Berg's and Juday's findings:

Chaoborus flavicornis	Maximum depth	Depth of larvae	Chaoborus punctipennis	Maximum depth	Depth of larvae
Esrom Lake	20M	Only below 15 meters	Lake Mendota	30M	Abundant only in depths; absent in shallows
			Lake Waubesa	11M	Present
Fredericksberg-Castle Lake	3M	Present	North Twin Lake Dredge cut	4M	Predominant bottom fauna
Sorte Dam	1M	Present			
			Undredged area	2M	Present
Temporary forest pools and ditches	1M	Present	Ditch near Ames, Iowa	1M	Present

The ditches and forest pools, only a few feet wide and deep, rich in organic matter, and protected from the wind, probably microstratify at times. They obviously provide the sort of protected environment that is favorable to Chaoborus larvae. It seems reasonable to assume that comparable protection is offered to Chaoborus in small lakes of moderate depths along the deepest areas of the bottom only. For example, North Twin Lake, approximately one square mile in area, provides Chaoborus habitat at only 12 to 14 feet in the bottom of the 135 acre dredge cut. In larger lakes, such as 15 square mile Lake Mendota, the bottom dwelling Chaoborus finds suitable refuge only in much deeper depressions. The larger size of Lake Mendota permits its active, well-aerated epilimnion to extend to a greater depth and hence the unoxygenated depths needed by

Chaoborus for protection are found at a greater distance from the surface.

Juday (1921) felt that larvae migrating to the surface at night were often carried over shallows by currents. However, they were not to be found established in shallow bottoms, even where the bottom types were seemingly suitable. He felt that either they made their way back to the depths or else they were lost. He speculated that they may return to deep water by return currents or by active migration, or that they suffered great losses to fish predation.

Lindquist and Deonier (1942) set large floating tent traps in horizontal series on Clear Lake, California, to catch emerging Chaoborus asticopus. They found that the pupae often drifted or swam hundreds of feet horizontally before reaching the surface. The pupae which had normally been living in deeper water tended to move into protected shallows to emerge. Emergence was at night in calm warm weather.

They found that total emergence was always far less than total larval counts. Only about one-fifth of the larvae or thereabouts successfully emerged. They decided that most of this heavy mortality of Chaoborus occurred because the pupae moved into the shore zone where they were heavily preyed upon by fish. They found that the larvae were always much more numerous in the bottom samples, but in the fish stomachs (Sacrament perch, White crappie, and Bluegill) the pupae were sometimes nearly as abundant as larvae.

Miller (1941) found two separate periods of emergence of adult Chaoborus punctipennis in Costello Lake, Ontario. The first emergence was from late June through early July. No adults were caught in August, but in September, adults were again numerous.

Miller demonstrated from a continuous series of bottom samples that the first wave of adults were from the overwintering larvae. The large population of overwintering larvae declined in numbers and disappeared by late July as the first emergence was concluded. In August, the minute second generation larvae began to appear in the bottom samples. Adults from this generation began to emerge in September.

The deep water of Costello Lake varies from 4°C to 8°C during the summer. Miller believed that the constancy of the environment in the bottom of this small deep lake accounted for the clean-cut distinctness of the two *Chaoborus* generations.

2. Methods

An attempt was made to determine the number of generations of *Chaoborus punctipennis* in North Twin Lake by a modification of the method of Miller (1941). It was hoped that each successive generation of the midge larvae could be followed through its growth and emergence from a series of length-frequency graphs prepared from the lengths of the organisms taken from the series of bottom fauna samples.

All *Chaoborus punctipennis* larvae were measured to the nearest millimeter; and, using the number of larvae in each millimeter size group, a length-frequency graph was constructed for each transect for each particular sampling period.

3. Results and discussion

Many of the length-frequency graphs of the number of larvae in each one-millimeter size group were unimodal. The unimodal graphs showed a wide range of length groups and probably indicate overlapping of several generations, but no clear indication of a distinct succession of separate generations such as Miller found in Costello Lake.

Lindquist and Deonier (1943) found that the number of generations of Chaoborus asticopus per year in Clear Lake, California, could not ordinarily be computed by the length-frequency method because of overlapping of generations.

North Twin Lake is extremely warm and shallow, compared to Costello Lake, Ontario. It is believed probable that in the optimum conditions of North Twin Lake, after the emergence of the first adult Chaoborus, that there may be a more or less continuous emergence and swarming of adults through the summer so that generations tend to overlap each other. Overlapping of generations could cause the unimodal distribution of length-frequencies observed and prevent the determination of numbers of generations by this method.

Another difficulty in the use of the length-frequency method may be caused by differences in habits of smaller and larger larvae. The smaller Chaoborus larvae may tend to escape or avoid the Ekman dredge more than the larger larvae. The larger larvae are burrowing in habit whereas the smaller larvae tend to be free-swimming near the bottom.

A few of the graphs selected and presented in Fig. 8 seem to indicate the possibility of three generations of Chaoborus punctipennis per year in North Twin Lake. Table 17 shows that Chaoborus punctipennis larvae had the widest range in sizes in July and August, further evidence that more than one generation were actually present during the summer at North Twin Lake.

Muttkowski (1918) observed that Chaoborus punctipennis emerged from

Fig. 8. Frequency of occurrence of larvae of different lengths from selected sampling periods in North Twin Lake in 1951, 1952 and 1954. Larval length in millimeters.

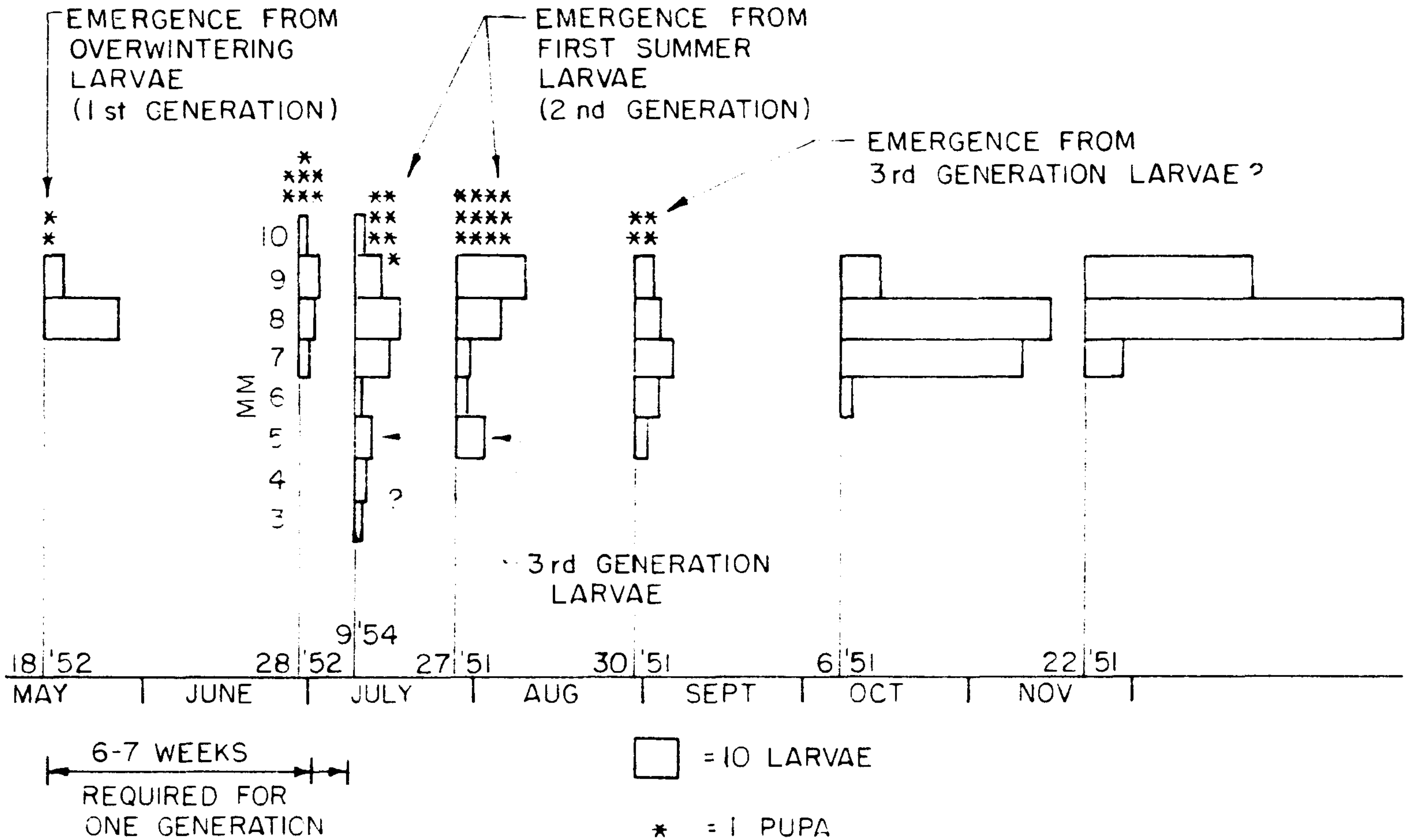

EMERGENCE FROM OVERWINTERING LARVAE (1st GENERATION)
EMERGENCE FROM FIRST SUMMER LARVAE (2nd GENERATION)
EMERGENCE FROM 3rd GENERATION LARVAE ?
MM
10
9
8
7
6
5
4
3
?
3rd GENERATION LARVAE
18 '52
28 '52
9 '54
27 '51
30 '51
6 '51
22 '51
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
6-7 WEEKS
REQUIRED FOR ONE GENERATION
= 10 LARVAE
* = 1 PUPA

Table 17. Percentage of Chaoborus punctipennis larvae in each millimeter size-group by months in North Twin Lake. All samples combined.

Months	Lengths in millimeters 3	4	5	6	7	8	9	10	11	Pupae
March		.05	.5	1.8	9.5	62.8	24.5	.95		
April		.37	.37	6.0	11.2	59.2	21.3	1.5		
May			.55	2.2	19.2	61.5	13.7	1.1		1.6
June			1.1	2.2	9.4	34.8	29.2	4.5	.75	16.9
July	.05	.73	5.0	9.1	30.1	32.6	10.6	2.3	.16	9.4
August	.3	1.7	13.2	13.1	34.1	26.3	4.3	.3	.1	6.5
September				.6	9.9	77.1	12.2	.1		
October			.2	4.5	36.2	56.2	2.9			
November			.1	1.9	10.9	64.6	22.5	.1		
December and January				1.2	8.4	63.6	16.0	.8		

Lake Mendota, Wisconsin, as early as May and as late as September, with heaviest emergence in June through August. He reasoned that there could be as many as three complete generations in the summer in Lake Mendota.

At North Twin Lake, pupae were observed as early as May 18 and as late as August 30. Adults were captured through the summer in 1954 from June 25 until September 1, but no attempts at collection were made before June 25 or after September 1.

Lake Mendota is some 15 square miles in area and up to 30 meters deep. North Twin Lake is much smaller and more shallow, and is well within the limits of temperate third-order lakes described by Usinger (1956). Usinger characterizes third-order lakes as those about 25 feet in depth or less, whose bottom temperatures are at or near those of the surface. It would seem virtually certain that in normal years North Twin Lake should be warmer throughout its depths over a longer period of time than would Lake Mendota.

In North Twin Lake there are probably at least three generations of *Chaoborus* per year, but more exact information cannot be secured from the present studies.

C. Chironomidae

1. Review of life histories and discussion

The larvae of several species of Chironomidae are present in the quiet-littoral zone of North Twin Lake. Larvae of Chironomidae are difficult or even impossible in some cases to identify. Moreover, the number of the combined larvae of all species of Chironomidae was usually less than the number of *Chaoborus* larvae. It was deemed impracticable to attempt to make a length-frequency analysis to determine the number of generations per year of the various species of Chironomidae in North Twin Lake because of the difficulty of identifying or differentiating the species, and because of the likelihood of overlapping generations. Sadler (1935) reported great overlapping of generations in *Chironomus tentans* Fab., and Lindeman (1942) found overlapping of generations in other species of this family.

Collections of adult Chironomidae made around the shore of North Twin Lake during the summer of 1954 were identified by Dr. Willis Wirth of the United States National Museum. The following species were found:

Chironominae - *Tendipes* (=*Chironomus*) *decorus* (Joh.)
Tendipes (=*Chironomus*) *plumosus* (L.)
Tendipes (=*Chironomus*) *crassicaudatus* (Mall.)
Glyptotendipes lobiferus (Say)
Polypedilum digitifer Townes

Tanypodinae - *Coelotenypus concinnus* (Coq.)
Pelopia stellata (Coq.)

The greatest amount of the Chironomidae by weight in North Twin Lake consists of the larvae of about four species of closely related Chironominae. The two predominant species are thought to be *Tendipes* (=*Chironomus*) *plumosus* (L.) and *Tendipes* (=*Chironomus*) *decorus* (Joh.). These two species are nearly identical in morphology, and there seems to be no difference in habitat preference (Lindeman, 1942). For these reasons, Lindeman in his study of the midge fauna of Cedar Bog Lake, considered them together in calculating production. Lindeman also found that *Chironomus decorus* and *Chironomus plumosus* substituted for each other in different years at Cedar Bog Lake. In 1936 he found an abundant population of *Chironomus plumosus*, which was replaced by a sparse population of *Chironomus decorus* in 1937. In 1938 there was a mixed population of both species, and in 1939 a large population of both species. In 1940 both species declined in number. He felt that weather was probably responsible for the fluctuation of numbers of the two species.

Miller (1941) found that in Costello Lake, Ontario, where Chaoborus punctipennis and Chironomidae were both present in large numbers, that while Chaoborus had two generations per year, the Chironomidae had but one generation in two years. Miller felt that the Chironomidae were relatively handicapped because they were confined to the cold depths of the hypolimnion, while the Chaoborus migrated to the warm epilimnion every night.

Lindeman (1942) cited a series of authors who found a wide variance in the number of generations of Chironomidae produced per year in different lakes. Lundbeck (1926), working on the Grosser Ploner See, Wood (1938), on Lake Minnetonka, and Rempel (1936), at Lake Waskesin, found Chironomus plumosus to have only one generation per year in these large eutrophic lakes. Johnson and Munger (1930) found that Chironomus plumosus produced only two generations per year in Lake Pepin, an impoundment of the Mississippi River near La Crosse, Wisconsin. Ping (1917) found Chironomus decorus to have five generations per year at Ithaca, New York, with three generations between April and the end of July. Scott and Opdyke (1941) reported that the number of insects emerging from the water of eutrophic Lake Winona, Indiana, was much greater over shallow water than over deeper water, with a general but inexact association between greater emergence and higher bottom temperature.

Lindeman himself determined that three generations of Chironomus plumosus reached maturity in Cedar Creek Bog in the summer of 1940. He felt that three generations per year of Glyptotendipes lobiferus were produced there also.

Lindeman believed that the temperature of the bottom ooze, the habitat of the Chironomid larvae, was the controlling factor in the number of generations per year. He reminds us that this is in full conformity with the temperature-sum rule of insect development.

2. Conclusion

The number of generations of the species of the Chironomidae in North Twin Lake is not known. It is believed that at least three generations per year is the best estimate of the number of generations of Chironomus plumosus, Chironomus decorus, and Glyptotendipes lobiferus in North Twin Lake.

This estimate is based upon Lindeman's determination of three generations per year of these same three species in Cedar Bog Lake, about 35 miles north of Minneapolis, Minnesota. Lindeman felt that Cedar Bog Lake, because of its shallowness, warmed immediately throughout its depth, and gave maximum opportunity for insect development. North Twin Lake, while not so shallow as Cedar Bog Lake, does not stratify, and its bottom temperatures are in close adjustment with the entire water mass and the atmosphere. Since North Twin Lake is about 200 miles south of Cedar Bog Lake, it is probably somewhat warmer much of the year.

D. Production Rates

Since the best evidence indicates that both Chaoborus and the Chironomidae have three generations per year, it is probable that the production rates in the dredged and undredged areas are quite similar. Furthermore since North Twin Lake does not stratify, except for short periods in the summer, the temperatures in dredged and undredged areas are probably not greatly different. Therefore the comparisons of standing crops are probably fairly valid comparisons of production of these bottom organisms.

There may still be another factor to consider in comparing the two areas as producers of fish food - the availability of the organisms to fish.

VII. BOTTOM FAUNA: FORAGE RATIOS FOR CHAOBORUS PUNCTIPENNIS AND CHIRONOMIDAE

Hess and Swartz (1941) proposed the use of a ratio, termed the "forage ratio" to serve as an index to the preference of fish for items of the bottom fauna. Leonard (1941) suggested that the proposed index was instead a plausible method of measuring availability of the potential food item. Allen (1951) also judged the forage ratio to be an "availability factor." Hess and Tarzwell (1942) found in populations of *Anopheles* larvae preyed upon by the top minnow *Gambusia* that the forage ratio increased as the density of *Anopheles* larvae increased. They felt that *Gambusia* became more accustomed to feeding upon the larvae as the density increased.

Although the exact interpretation of the forage ratio might be debatable, it is felt that it is a useful index of the relative value of fish food organisms.

The forage ratio is obtained by dividing the percentage of a given kind of organism in the fish stomachs by its percentage in the environment.

Usinger (1956) expresses the forage ratio conveniently as follows:

$$FR = \frac{\frac{n}{N}}{\frac{n'}{N'}}$$

Where n is the number of any organism in the stomachs, N is the total number of organisms in the stomach, n' is the number of the same organism in the environment inhabited by the fish, and N' is the total number of food organisms in the environment. Weights or volumes may be substituted for numbers if desired.

In North Twin Lake the forage ratio was calculated for the Chironomidae and Chaoborus punctipennis (Say) using three species of fish, yellow bass, yellow perch, and black bullhead (Table 18). Fish for stomach content analysis were captured with gill-nets. The gill nets were set on the bottom sampling transects using equal numbers of gill-net hours of effort for each transect (Kutkuhn, 1954).

A forage ratio of one is interpreted to mean that the fish are feeding at random upon the organism in proportion to its abundance in the environment. A ratio of less than one indicates that the organism is fed upon less than its relative abundance should warrant. Burrowing forms, and tube and case dwelling forms are often less accessible to the fish.

The forage ratios indicate that in proportion to their respective abundance in the quiet-littoral zone, of North Twin Lake, Chironomidae were more utilized by fish for food during the dates given in Table 18.

It is realized that some allowance should be made for additional Chironomidae which were present in the erosion-littoral zone, and not accounted for in the quiet-littoral zone bottom samples. The additional Chironomidae would tend to lower the forage ratio. The erosion-littoral is relatively small, some 8 percent of the area of the lake, so its net effect on forage ratio should be small; however, the erosion-littoral zone is known to be an important food producing area, especially for small fish.

Table 18. Forage ratios of Chaoborus and Chironomidae in North Twin Lake. 1953 and 1954.

	Total fish stomachs examined	Diptera larvae in fish stomachs*: Percentage of total weight of stomach contents	Diptera larvae in fish stomachs*: Relative percentage	Diptera larvae in bottom fauna: Relative percentage in bottom samples	Diptera larvae in bottom fauna: Weighted percentage	Forage ratio
Yellow bass						
July-August, 1953	443					
Chironomidae		11.47	78.13	71.49	80.21	.97
Chaoborus		3.21	21.87	29.51	19.79	1.1
		14.68	100.00	100.00		
June-August, 1954	544					
Chironomidae		3.00	62.24	61.74	55.13	1.13
Chaoborus		1.82	37.76	38.26	44.87	.84
		4.82	100.00	100.00		
Yellow perch						
July-August, 1953	462					
Chironomidae		0.43	75.44	71.49	80.21	.94
Chaoborus		0.14	24.56	29.51	19.79	1.24
		0.57	100.00	100.00		
June-August, 1954	174					
Chironomidae		1.96	88.69	61.74	55.13	1.61
Chaoborus		0.25	11.31	38.26	44.87	.25
		2.21	100.00	100.00		
Black bullhead						
July-August, 1953	231					
Chironomidae		27.82	87.26	71.49	80.21	1.09
Chaoborus		4.06	12.74	29.51	19.79	.64
		31.88	100.00	100.00		
June-August, 1954	76					
Chironomidae		4.00	80,65	61.74	55.13	1.46
Chaoborus		0.96	19.35	38.26	44.87	.43
		4.96	100.00	100.00		

* From Kutkuhn, 1954.

VIII. THE EXTENT OF THE EROSION-LITTORAL ZONE IN NORTH TWIN LAKE IN 1954 AND SOME SPECIAL PROBLEMS AFFECTING THE VALUE OF THE EROSION-LITTORAL ZONE

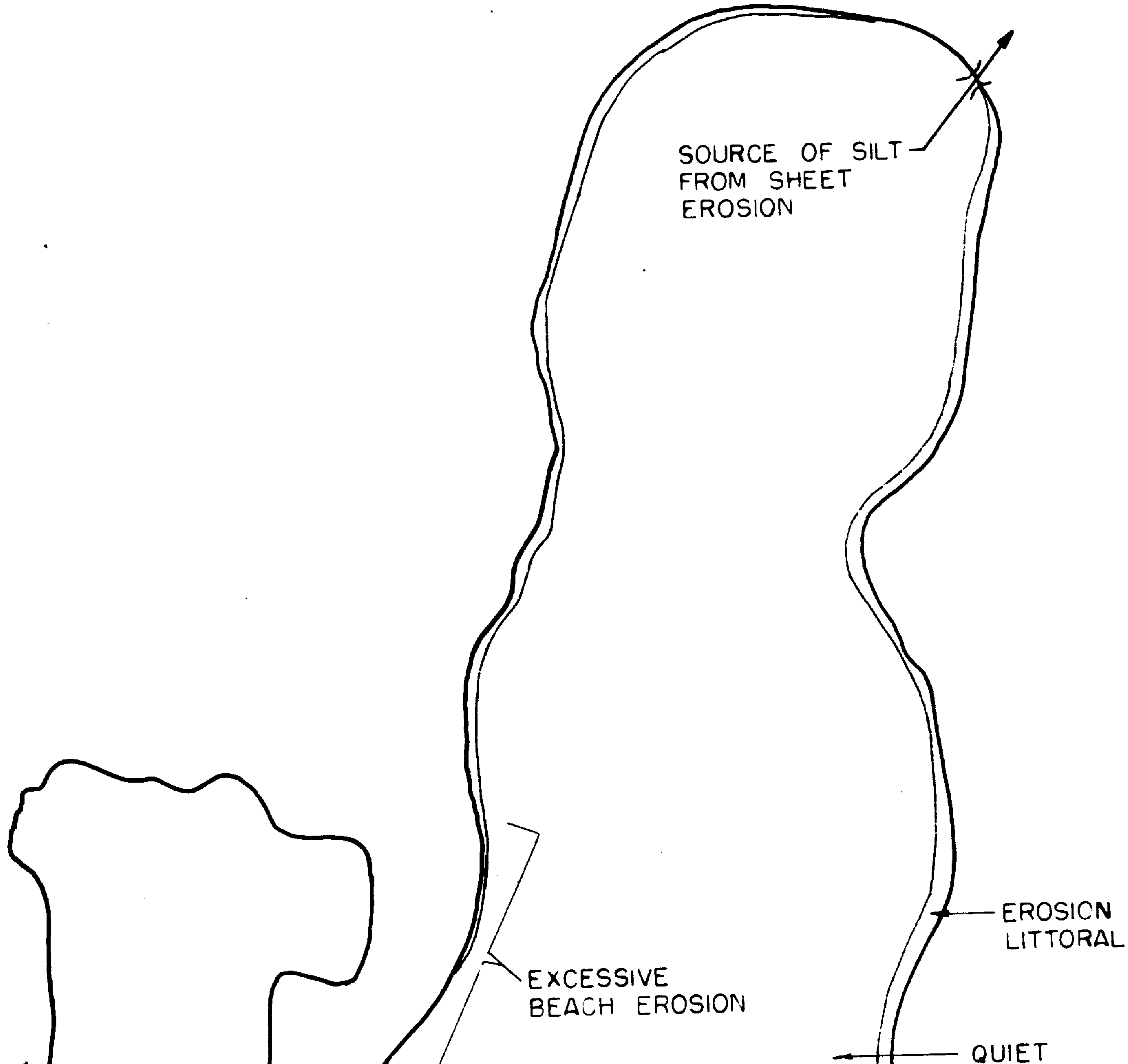
A. Methods

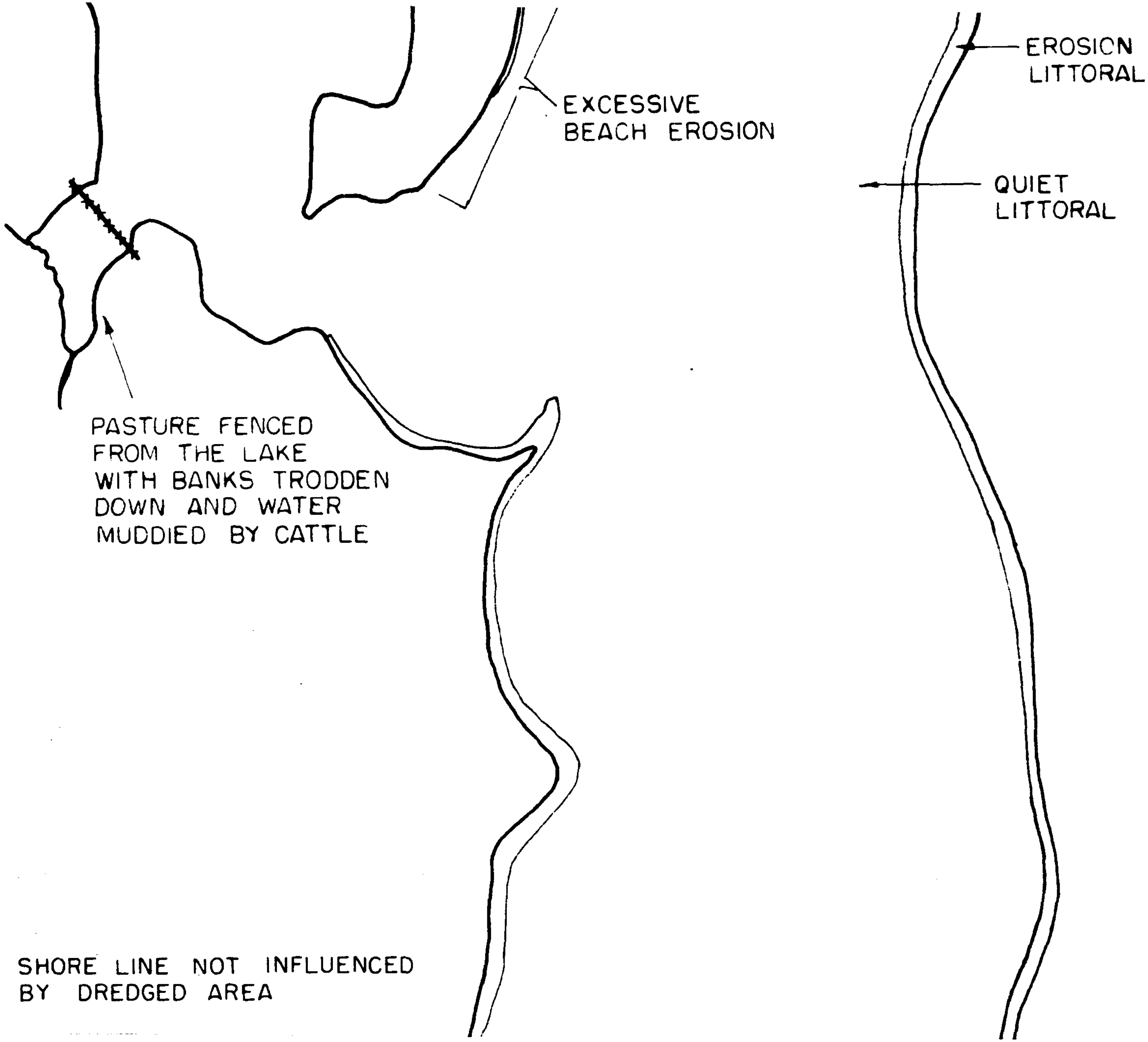
The erosion-littoral zone in North Twin Lake was mapped August 10 and 11, 1954, at a time when the lake surface was at the level of the sill of the outlet structure. The survey was made by going around the entire lake shore and at suitable intervals sampling the bottom from the water's edge out into the lake along a graduated line perpendicular to the shore. The bottom was sampled by surface-diving, and the width of the erosion-littoral zone was taken to be the extent of the clean sandy bottom from the water's edge out to where the sand was replaced by silt or sediments.

Examination of the map (Fig. 9) of the sandy erosion-littoral zone suggested that the clean, wave-washed shore zone might be substantially wider in the southern end of the lake. It was felt that perhaps the dredge cut in the southern end of the lake might be a factor in assisting in the maintenance of a wider erosion-littoral area in that end.

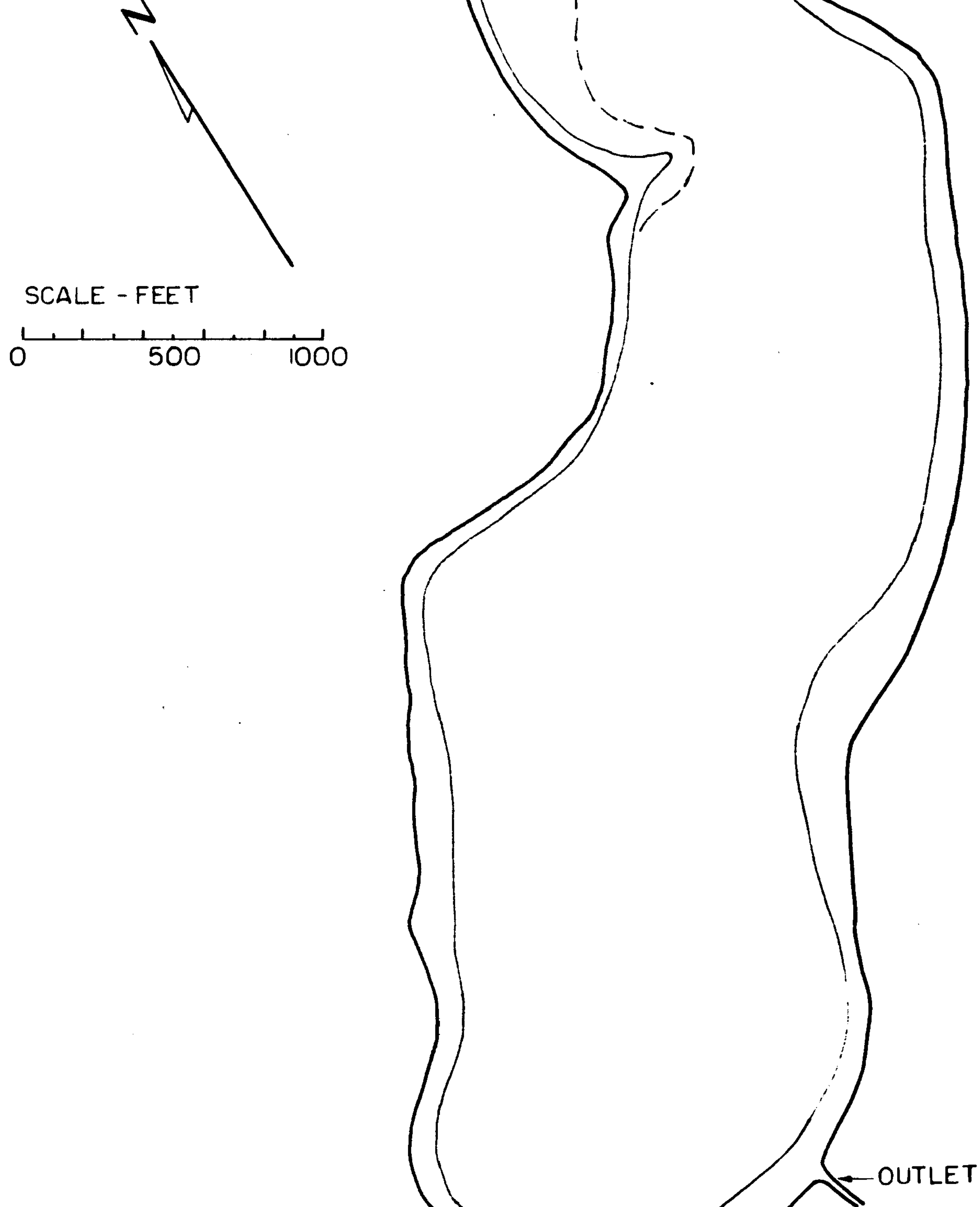
The outline of the lake on the map was arbitrarily divided into two portions by a line drawn across the lake at the northern end of the dredged area (Fig. 9). The average width of the erosion-littoral zone was found to be 57 feet in the northern undredged end and 77 feet in the southern dredged end of the lake. The area of the erosion-littoral zone in the southern end was 9.33 acres per mile of shore line for a total of 24.0 acres for the 2.57 miles in that end. In the northern segment, there were 3.03

Fig. 9. North Twin Lake. Extent of the erosion-littoral and quiet-littoral zones in 1954.


SOURCE OF SILT
FROM SHEET
EROSION
EROSION
LITTORAL
EXCESSIVE
BEACH EROSION
QUIET



EXCESSIVE BEACH EROSION
EROSION LITTORAL
QUIET LITTORAL
PASTURE FENCED FROM THE LAKE WITH BANKS TRODDEN DOWN AND WATER MUDDIED BY CATTLE
SHORE LINE NOT INFLUENCED BY DREDGED AREA


N
SCALE - FEET
0
500
1000
OUTLET

miles of shore line with 6.91 acres of sandy littoral zone per mile for a total of 20.9 acres.

B. Sources of Silt and Sedimentation

During the survey of the shore line, some particular areas of what appeared to be excessive erosion were seen. There were three such areas of accelerated erosion, each of which seemed to be a source of undue amounts of silt entering the lake basin. The first area was a cultivated field embracing the northern end of the lake (Fig. 9). This field was in oats in 1954, and sheet erosion and minor gullying were much in evidence at that time (Fig. 10). At a time of low water earlier in the season, this field had been plowed and a seed bed prepared operating the farm equipment across the dry slough. The slough drains into North Twin Lake when there is sufficient run-off. At the time the photographs of Figs. 10 and 11 were taken, the unprotected soil of the field had been washed as far as the slough; at the next rain, much of the soil would go into the lake.

In the northern end of the lake, near the outlet of the culverts from the slough, there was direct evidence of periodic inflows of top soil. In places near shore, the former firm erosion-littoral sand could be felt through a layer of a few inches of soft black mud. In other places, about 8 inches of mud was overlain by a thin layer of sand. It appeared that a flood of mud came into the lake covering up the sandy erosion-littoral area; later, when the flow ceased, the situation stabilized, and fresh sand from the shore line gradually was spread over the new bottom. The layer of mud gave quantitative evidence of the extent to which the lake had been

Fig. 10. Sheet erosion in the oats field around the inlet into the northern end of North Twin Lake. (May 15, 1954)

Fig. 11. Loose earth from excessive erosion from the field shown in Fig. 10 accumulated at the mouth of the culvert leading into North Twin Lake. (May 15, 1954)

filled in a short time.

A second place of rapid erosion and source of sedimentation was found along the low cut banks north of the entrance to Muddy Bay (Fig. 12). Here the waves were undercutting the unprotected earthen banks and depositing the clay and topsoil on a low soft fore shore which extended to the permanent silt of the quiet-littoral bottom.

It appears that major undercutting of the banks along this stretch of shore occurs only at peak water levels. Lowering of the water level a foot or so would probably allow the wave action to clean the fore shore of the top layer of clay and reestablish a more typical firm sandy erosion-littoral zone. Nevertheless, each time the water comes to a peak level, many tons of material from these unprotected banks are swept into the lake and thus speed the filling process.

There was yet a third example of aggravated erosion of a perennial type that is well known in Iowa and elsewhere as being especially destructive to aquatic recreational areas. An area of several acres in an arm of Muddy Bay was fenced from the lake and included in a cattle pasture. The pasture was only a moderate sized one and probably was being used as a feeding lot, for a herd of from 30 to 50 cattle was present on August 11, 1954 (Figs. 9 and 13). The field and the marshy borders of the arm of Muddy Bay were heavily trampled and the waters were muddy and filthy.

During the summer and fall of 1955, the lake level dropped about 30 inches. The water in Muddy Bay receded so that it did not reach the cattle lot. The farmer extended his electric fence system so that a passageway was opened to the south shore of the entrance to Muddy Bay. There the pollution and trampling was much nearer to the main body of the lake.

Fig. 12. North Twin Lake. Excessive beach erosion and bank sloughing along the western side north of Muddy Bay. (August 11, 1954)

Fig. 13. North Twin Lake. Arm of Muddy Bay fenced from the lake and heavily trampled by cattle. A stand of Typha sp. thrives on the other side of the fence.

C. Fish Food Organisms of the Erosion-Littoral Zone

A total of 128 one-quarter square foot Ekman dredge samples was taken in the erosion-littoral zone during the summers of 1953 and 1954. The shore samples were taken at depths of from one to two and one-half feet and from 8 to 20 feet from the water's edge. Bottom types were sand of varying degrees of coarseness with some amounts of silt and debris on occasion.

The shore samples were taken to obtain specimens for qualitative comparison with the bottom fauna of the quiet-littoral zone and to determine the habitat location of bottom fauna organisms which were found in fish stomachs.

No estimates were made of the number of 36 square inch Ekman samples needed to obtain a stated degree of accuracy. Tebo (1955) sampled the erosion-littoral zone at comparable depths at Lizard Lake about 15 miles from North Twin Lake with a device which sampled an area of 38.48 square inches. He calculated that 54 such samples were needed to keep the standard error within 10 percent of the mean.

The fauna of the erosion-littoral zone of North Twin Lake could be well characterized by the two species which are by far the most prominent. These are nymphs of Caenis sp. (Ephemeroptera) and larvae of Oecetis inconspicua (Walker) (Trichoptera). Caenis sp. occurred in nearly every shore sample, with as many as 17 being taken in one one-quarter square foot haul. Oecetis inconspicua is ideally adapted to the erosion-littoral zone of North Twin Lake, as it makes its case of sand grains cemented together, weighted with a small pebble or two on each side.

A group of exceedingly small Chironomid larvae were present in numbers in the shore zone also. These Chironomidae were one to two millimeters in length, some were green, some whitish or red. They appeared to be different species from Chironomid larvae of the quiet-littoral zone.

Rare organisms of the shore zone included a few Ceratopogonidae, one or two Chaoborus punctipennis, other unidentified diptera larvae and pupae, and a few beetle larvae. Oligochaeta were found in some areas where debris or silt had collected.

D. Discussion

The true importance of the erosion-littoral zone in the ecology of the fishes of North Twin Lake would be exceedingly difficult to measure. However, it is believed that the erosion-littoral zone is of very much greater value to the sport fishery than perhaps a quantitative or comparative estimate of the weights of the bottom fauna of fish food produced there might indicate.

The shallows of the erosion-littoral zone provide the essential spawning areas for many species of fish. The young of most species in North Twin Lake are also reared in the shore areas. The erosion-littoral areas are utilized as feeding grounds for intermediate sized yellow perch and yellow bass. Kutkuhn (1954) found the stomach contents of yellow perch and yellow bass to include Caenis sp. and Oecetis sp. from the shore zone. Larger individuals of these species and species of game fish such as walleye visit the shore zone to capture young fishes and forage fishes of all species.

A distinction should be made between the stabilized erosion-littoral area which has a clean sandy substrate and the unstable fresh deposits in the erosion-littoral area such as were found at the foot of the cut banks north of Muddy Bay (Figs. 9 and 12). Freshly deposited material from eroded soil is almost totally unproductive of fish food. In this respect, the temporary mud flats within the erosion-littoral area should not be confused with the productive stabilized quiet-littoral mud bottom from the same source material.

In summation, it would seem that the greatest factor involving the erosion-littoral zone lying within the scope and power of the fisheries manager would be the stabilization or protection of the zone against undue erosion. Protection against beach erosion and protection of the watershed against sheet erosion would preserve the extent of the sandy littoral zone which has a high value esthetically as well as being of fundamental value in the fisheries ecology of the lake. Prevention of undue erosion would also materially delay the filling of the lake basin and protect the public investment in this valuable recreational site.

Some of the thorniest problems of the fishery-management biologist often stem from the natural maturation of lakes. Within a few decades a lake may change from a deep cold trout lake to a more shallow cool perch or walleye lake. Or another lake may fill with sediments and change from a walleye lake of moderate depth into a still more shallow warm bullhead lake, and still further into a critically shallow marsh unsuitable for fish life.

The precipitating cause of the entire problem leading to the dredging of North Twin Lake was obviously the filling of the lake basin. The utmost effort to prevent further siltation would merit serious consideration. The Iowa Twenty-five Year Plan, published by the Iowa State Conservation

Department, recommends fencing cattle from public lakes, beach erosion control, and controlling of field erosion in a "Typical Lake Improvement Plan" (Crane and Olcott, 1933).

Most of the immediate watershed surrounding North Twin Lake is privately owned. The fields and pasture, however they may adversely affect the public waters of North Twin Lake, are not subject to management by the state. It would seem that key strips of beach, or sloughs leading into North Twin Lake should be considered for purchase so that permanent erosion control measures could be initiated.

It is perhaps significant that most of the private cottage owners along the eastern shore of the lake have rip-rapped or built concrete retaining walls along their lake frontage. The erosion-littoral zone along this stretch of beach is wide and clean and quite attractive.

The location of the dredged area seems to have an effect on the width of the erosion-littoral zone. It appears that silt in the south end of the lake near the dredge-cut may settle eventually into the dredged area and be removed. The silt in the north end has no such place to go and repeatedly is stirred up by storms only to settle near shore again at times of calm.

It might seem advisable to dredge a long narrow cut through the long axis of such a lake as North Twin, thereby increasing the width of the clean sandy erosion-littoral zone through the entire length of the lake. Attention should be paid to promentories such as the point and bar near the south entrance to Muddy Bay and the point opposite the state park. The bars out from such points probably should be left undredged; they are swept clean by currents and both areas in North Twin Lake are favorite fishing spots.

IX. SUMMARY AND CONCLUSIONS

1. Several Iowa lakes have been dredged to increase their recreational value. The present study was undertaken to determine some of the effects of this dredging on the bottom fauna. North Twin Lake in Calhoun County is long and narrow, covering an area of about 509 acres. About 92 percent of the lake bottom is mud, comprising the quiet-littoral zone; the remainder of the lake bottom is the wave-washed sand of the erosion-littoral zone. The southern end of the lake was dredged to a depth of from 14 to 18 feet in 1939 and 1940.

2. Bottom samples were taken with a quarter square foot Ekman dredge in the quiet-littoral zone along a number of transects perpendicular to the long axis of the lake, with two transects in the undredged and two in the dredged zone. Collections were made at 17 periods from July 1951 to August 1954.

3. The predominant organisms of the bottom fauna of the quiet-littoral zone were the larvae of Chaoborus punctipennis (Say) and the larvae of the Chironomidae. Oligochaeta occurred in numbers in all areas of the lake but were found not to be fed upon by fish and so were not studied.

4. It was found that the number of Chaoborus varied little among locations across the lake at each transect. The principal source of variation was along the long axis of the lake. Hence increasing the number of transects and decreasing the number of samples on each transect materially increased the efficiency of the sampling design.

5. Chaoborus larvae from Ekman dredge bottom samples taken in pairs

at one location often showed statistically different mean lengths and abundance. It is known that the smaller larvae are free-swimming near the bottom, while the larger larvae are burrowing in habit during the daylight hours. It was suggested that the taking or washing of the first dredge sample at one location may so disturb the actively swimming smaller larvae that the second sample might take a higher proportion of the larger larvae. *Chaoborus*, then, might be sampled more accurately by taking single samples from a greater number of locations.

6. *Chaoborus* were more numerous in the dredged than in the undredged zone. Their numbers and weights decreased in the summer, due to the emergence of adults. This numerical decrease in the dredged area was relatively greater in its shallow areas.

7. Larvae of Chironomidae were present in substantial numbers in both the dredged and undredged zones during all seasons of the year. Chironomidae were more numerous in the dredged zone at all seasons except during July and August, when a somewhat larger standing crop of Chironomidae was found in the undredged zone.

8. The average annual standing crop of *Chaoborus* and Chironomidae was 33.1 pounds (wet weight) per acre in the dredged area compared to 16.6 pounds in undredged. On the basis of pounds of crude protein, the comparable figures were 1.89 pounds for the dredged area and 0.70 pounds for the undredged.

9. It was estimated that *Chaoborus punctipennis* and several of the important species of Chironomidae have three generations per year in both dredged and undredged portions of North Twin Lake. Therefore annual standing crops are probably proportional to the rate of production in the two areas.

10. Forage ratios calculated for *Chaoborus* and Chironomidae indicated

that black bullhead in 1953 and 1954 and yellow perch and yellow bass in 1954 fed upon a greater percentage of Chironomidae and a lesser percentage of Chaoborus than the comparable percentage of these organisms in the lake bottom. In 1953 yellow perch fed upon Chironomidae in approximately the same ratio as its occurrence in the bottom fauna and fed upon Chaoborus at a somewhat higher ratio than its relative occurrence in the bottom fauna. Yellow bass in 1953 selected Chironomidae and Chaoborus in proportions approximately equal to their relative abundance.

11. The relative availability of bottom fauna from the dredged zone is unknown. It has been shown that the standing crop of bottom fauna or potential fish food per unit area is greater in the dredged zone than in the undredged zone at all times of the year. Yet if we interpret the low forage ratio of Chaoborus, the typical organism of the dredged zone, as being a measure of the relative unavailability of this insect, then the Chironomidae of the dredged zone may be equally unavailable. It cannot be told if the Chironomidae of the fish stomach contents come from the dredged zone in part or wholly from the undredged zone.

12. Sheet erosion of the watershed of North Twin Lake and beach erosion appear to be affecting the lake adversely by covering up the sandy erosion-littoral zone with silt. It is suggested that steps should be taken to limit erosion and undue sedimentation affecting North Twin Lake.

13. The sandy-erosion-littoral zone in North Twin Lake appears to be wider in proximity to the dredged area. It is suggested that perhaps the sandy littoral zone could be enlarged in lakes that may be dredged in the future by making the dredge cuts through the long axis of the lake, rather than in one end.

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XII. APPENDIX

Table 19. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 25, 1951. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1A								2	
4-1B	3	1						3	
4-2A	1		.002	1	.005	1	.002		
4-2B	1		.002	6	.090	8	.018	4	
4-3A	2							8	
4-3B	2							2	1 adult Diptera
4-4A	3		.006	2	.050	12	.010	8	
4-4B	2		.004	5	.070	12	.030	2	1 Mollusc
4-5A								1	
4-5B	2	1						3	
Transect totals	16	2						33	

	Chaoborus	Chironomidae
Grams wet weight per square foot	.014	.275
Milligrams protein per square foot	.840	14.06

Table 20. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 27, 1951. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
5-1A	9							10	
5-1B	2	1						7	
5-2A				9	.125	21	.070	12	
5-2B	4		.007	10	.110	14	.040	6	
5-3A	4	4						2	2 molluscs 2 Tendipes adults
5-3B	4							2	1 Ceratapogonidae
5-4A	2		.003	16	.180	19	.050	4	
5-4B	3	2	.004	5	.075	8	.025	5	
5-5A	3	1						6	
5-5B	4	3						1	
Transect totals	35	11						55	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.014	.675
Milligrams protein per square foot	.840	34.5

Table 21. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 22, 1951. Transect 8.

Sample number	Chaoborus Larvae	Chaoborus Pupae	Chaoborus Wet weight (gms.)	Chironomidae: Chironominae Number	Chironomidae: Chironominae Wet weight (gms.)	Chironomidae: Other Chironomidae Number	Chironomidae: Other Chironomidae Wet weight (gms.)	Oligochaeta Number	Miscellaneous Number
8-1A			*	*	*	*	*	2	
8-1B	1		*	*	*	*	*	1	
8-2A		1		4	.110	6	.015	1	
8-2B	1		.002	7	.190	3	.005	2	
8-3A	2		*	*	*	*	*	3	
8-3B		1	*	*	*	*	*		
8-4A	3		.008	2	.075	7	.020	5	
8-4B	2		.003	5	.120	3	.005	1	
8-5A			*	*	*	*	*	1	
8-5B			*	*	*	*	*	1	
Transect totals	9	2	*	*	*	*	*	17	

	Chaoborus	Chironomidae
Grams wet weight per square foot	.013	.540
Milligrams protein per square foot	.780	27.6

* Not calculated.

Table 22. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 24, 1951. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1A	15	3						2	
9-1B	3								
9-2A	13		.031	2	.070	3	.002		
9-2B	9	5	.016	1	.025	8	.005		
9-3A	6	2						1	
9-3B	4	3							
9-4A	10	2	.017			3	.003		
9-4B	8	3	.010	9	.200	8	.008		
9-5A	7	7						1	
9-5B	2	4						1	1 snail
Transect totals	77	29						5	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.074	.313
Milligrams protein per square foot	4.44	16.0

Table 23. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, August 30, 1951. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1A	5							3	
4-1B	4								
4-2A				1	.005	3	.003		
4-2B		1		1	.005	2	.002		
4-3A	1								
4-3B								1	
4-4A				3	.050	7	.010		
4-4B				1	.020	10	.020	3	
4-5A	2							1	
4-5B	1								
Transect totals	13	1						8	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.000	.115
Milligrams protein per square foot	.000	5.88

Table 24. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, August 30, 1951. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
5-1A	8								
5-1B		1						2	1 Ceratopogonidae
5-2A				3	.015	3	.004	6	
5-2B				5	.075	3	.006	3	
5-3A	2	1						18	1 Caddis
5-3B	6							10	3 Ceratopogonidae
5-4A	2		.002	4	.080	16	.030	11	
5-4B	6		.009	4	.100	3	.005	2	
5-5A		2						8	
5-5B	1							5	
Transect totals	25	4						65	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.011	.315
Milligrams protein per square foot	.591	16.1

Table 25. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, August 29, 1951. Transect 8.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
8-1A	4	1							
8-1B	4								
8-2A	1	1	.002			3	.007	1	
8-2B	5	1	.006	2	.050	5	.013	1	1 adult Diptera
8-3A	9	3						2	
8-3B	6	3						3	
8-4A	1		.001			3	.004		
8-4B	4	2	.005	1	.030	1	.001		
8-5A	1	1							
8-5B	2	3							
Transect totals	37	15						7	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.014	.105
Milligrams protein per square foot	.753	5.37

Table 26 . Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, August 29, 1951. Transect 9.

Sample number	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1A	36	2	*	*	*	*	*		2 Nemato-
9-1B	33	2	*	*	*	*	*	1	morpha
9-2A	30		.027			8	.005		
9-2B	19	2	.019			7	.005		
9-3A	29	1	*	*	*	*	*		
9-3B	13		*	*	*	*	*		
9-4A	5	1	.006			3	.004		
9-4B	30	2	.028			15	.021		
9-5A	18	1	*	*	*	*	*		1 cater-
9-5B	17		*	*	*	*	*		pillar (terrestrial)
Transect totals	230	11	*	*	*	*	*	1	

	Chaoborus	Chironomidae
Grams wet weight per square foot	.080	.035
Milligrams protein per square foot	4.30	1.79

* Not calculated.

Table 27 . Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, October 6, 1951. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1	7		.008			8	.015	2	
4-2	4		.004			3	.003	10	
4-3	3		.004			6	.007	1	
4-4	5		.008	1	.015	11	.020	2	1 Ceratopogonidae
4-5	10		.015			7	.010	7	
Transect totals	29		.039	1	.015	35	.055	22	

	Number	Wet weight (gms.)
Total Chironomidae	36	.070

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0312	.056
Milligrams protein per square foot	1.95	2.86

Table 28. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, October 6, 1951. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
5-1	8		.012			6	.015	6	
5-2	16		.023			5	.020	7	
5-3	21		.032			19	.040	12	
5-4	13		.019			15	.030	17	
5-5	15		.023			17	.030	12	
Transect totals	73		.109			62	.135	54	

	Number	Wet weight (gms.)
Total Chironomidae	62	.135

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0872	.108
Milligrams protein per square foot	5.45	5.52

Table 29. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, October 6, 1951. Transect 8.

Sample number	Chaoborus: Larvae	Chaoborus: Pupae	Chaoborus: Wet weight (gms.)	Chironomidae: Chironominae: Number	Chironomidae: Chironominae: Wet weight (gms.)	Chironomidae: Other Chironomidae: Number	Chironomidae: Other Chironomidae: Wet weight (gms.)	Oligochaeta: Number	Miscellaneous: Number
8-1	12		.018	2	.030	4	.005	1	
8-2	21		.034	2	.030	3	.005	5	
8-3	29		.049	5	.090			1	
8-4	8		.011	5	.030	3	.004	2	
8-5	14		.023	11	.100	2	.002		
Transect totals	84		.135	25	.280	12	.016	9	

	Number	Wet weight (gms.)
Total Chironomidae	37	.296

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.108	.2368
Milligrams protein per square foot	6.76	12.1

Table 30. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, October 6, 1951. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1	115		.166	7	.040	14	.015		1 Ceratopogonidae
9-2	69		.104		*		*		1 Ceratopogonidae
9-3	66		.094	22	.140	8	.005	1	
9-4	95		.131	4	.020	14	.005	1	1 Ceratopogonidae
9-5	63		.092	1	.030	1	.001	4	1 Ceratopogonidae
Transect totals	408		.587	34	.230	37	.025	6	

	Number	Wet weight (gms.)
Total Chironomidae	71	.255

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.4696	.255
Milligrams protein per square foot	29.4	13.0

* Data missing.

Table 31 . Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, November 22, 1951. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
5-1	6		.010	2	.005	8	.010	4	
5-2	16		.030			11	.030	3	1 *Hexagenia limbata*
5-3	16		.026			11	.030	8	
5-4	16		.030			13	.030	9	
5-5	12		.023	2	.005	11	.030	6	
Transect totals	66		.119	4	.010	54	.130	30	

	Number	Wet weight (gms.)
Total Chironomidae	58	.140

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0944	.112
Milligrams protein per square foot	5.64	5.72

Table 32. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, November 22, 1951. Transect 8.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
8-1	15		.024	3	.040	9	.030	4	
8-2	24		.036	3	.060	13	.010	6	
8-3	16		.029	1	.025	14	.020	4	
8-4	15		.023	1	.025	12	.020	3	
8-5	5		.010			9	.025	1	1 nematomorpha
Transect totals	76		.122	8	.150	57	.105	18	

	Number	Wet weight (gms.)
Total Chironomidae	65	.255

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0976	.204
Milligrams protein per square foot	5.83	10.4

Table 33. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, November 22, 1951. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1	20		.029			14	.005	2	
9-2	52		.076			7	.002		
9-3	38		.060	1	.025	7	.002	1	
9-4	46		.069	2	.060	6	.002		
9-5	32		.045	2	.070	2	.001		
Transect totals	188		.279	5	.155	36	.012	3	

	Number	Wet weight (gms.)
Total Chironomidae	41	.167

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.223	.134
Milligrams protein per square foot	13.3	6.85

Table 34. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, January 1, 1952. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1	2		.004	1	.001	8	.010	9	
4-2	3		.005	2	.005	5	.020	7	
4-3	5		.011			21	.030	10	
4-4	5		.008			3	.010	3	
4-5	7		.009	4	.010	10	.005	7	
Transect totals	22		.037	7	.016	47	.075	36	

	Number	Wet weight (gms.)
Total Chironomidae	54	.091

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0296	.073
Milligrams protein per square foot	1.62	3.73

Table 35. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, December 31, 1951. Transect 5.

Sample number	Chaoborus Larvae	Chaoborus Pupae	Chaoborus Wet weight (gms.)	Chironomidae: Chironominae Number	Chironominae Wet weight (gms.)	Other Chironomidae Number	Other Chironomidae Wet weight (gms.)	Oligochaeta Number	Miscellaneous Number
5-1	24		.037	3	.005	13	.020	26	
5-2	14		.021			25	.050	14	
5-3	29		.055	2	.010	11	.030	49	
5-4	24		.041			25	.020	50	1 Ceratopogonidae 1 Mayfly nymph *
5-5	19		.032	4	.075	9	.030	11	1 Caddis
Transect totals	110		.186	9	.090	83	.150	150	* Hexagenia limbata

	Number	Wet weight (gms.)
Total Chironomidae	92	.240

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.1488	.192
Milligrams protein per square foot	8.90	9.81

Table 36. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, January 1, 1952. Transect 8.

Sample number	Chaoborus Larvae	Chaoborus Pupae	Chaoborus Wet weight (gms.)	Chironomidae: Chironominae Number	Chironomidae: Chironominae Wet weight (gms.)	Chironomidae: Other Chironomidae Number	Chironomidae: Other Chironomidae Wet weight (gms.)	Oligochaeta Number	Miscellaneous Number
8-1	10		.014			12	.020	5	
8-2	8		.013	2	.060	12	.020	5	1 Ceratopogonidae
8-3	7		.010	4	.140	7	.010	2	
8-4	20		.033	3	.100	7	.015	9	
8-5	12		.017	4	.090	4	.002	2	
Transect totals	57		.087	13	.390	42	.067	23	

	Number	Wet weight (gms.)
Total Chironomidae	55	.457

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0696	.366
Milligrams protein per square foot	3.82	18.7

Table 37. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, December 25, 1951. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1	64		.107	4	.090	10	.010		
9-2	71		.125			4	.005		1 Ceratopo-gonidae
9-3	52		.095	3	.090	7	.010		
9-4	58		.102	4	.060	10	.010		1 Ceratopo-gonidae
9-5	33		.056	1	.070	6	.030		
Transect totals	278		.485	12	.310	37	.065		

	Number	Wet weight (gms.)
Total Chironomidae	49	.375

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.388	.300
Milligrams protein per square foot	23.2	15.3

Table 38. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, April 12, 1952. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1	7		.010	1	.040	7	.020	5	
4-2	3		.007	2	.010	5	.005	12	1 Ceratopogonidae
4-3	4		.004	1	.002	8	.002	11	
4-4	1		.001	1	.005	5	.005	15	
4-5	4		.006	1	.015	4	.010	12	
Transect totals	19		.028	6	.072	29	.042	55	

	Number	Wet weight (gms.)
Total Chironomidae	35	.114

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0224	.0912
Milligrams protein per square foot	1.20	4.66

Table 39. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, April 12, 1952. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet Weight (gms.)	Number	Number
5-1	4		.006	1	.025	8	.010	13	
5-2	9		.014	1	.002	14	.015	9	
5-3	9		.016			6	.010	6	
5-4	11		.018	2	.070	7	.020	9	
5-5	7		.011			14	.015	16	1 Ceratopogonidae
Transect totals	40		.065	4	.097	49	.070	53	

	Number	Wet weight (gms.)
Total Chironomidae	53	.167

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.052	.134
Milligrams protein per square foot	2.79	6.85

Table 40. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, April 12, 1952. Transect 8.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
8-1	12		.021			7	.010	2	
8-2	7		.012	5	.160	15	.010	7	
8-3	14		.024	1	.010	2	.001		
8-4	2		.003			12	.020	12	
8-5	18		.030	3	.050	11	.025	1	
Transect totals	53		.090	9	.220	47	.066	22	

	Number	Wet weight (gms.)
Total Chironomidae	56	.286

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.072	.229
Milligrams protein per square foot	3.87	11.7

Table 41. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, April 12, 1952. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1	1		.002			7	.010	2	
9-2	56		.100	4	.005	10	.015	2	
9-3	27		.041			8	.010		
9-4	40		.059			8	.010	6	
9-5	30		.053			10	.020	4	
Transect totals	154		.255	4	.005	43	.065	14	

	Number	Wet weight (gms.)
Total Chironomidae	47	.070

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.204	.056
Milligrams protein per square foot	11.0	2.86

Table 42. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, May 18, 1952. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1	2		.004	1	.001	12	.030	10	
4-2	5	1	.009			10	.030	6	
4-3	3		.005			21	.050	7	1 Ceratopogonidae
4-4	1		.002	1	.040	13	.030	20	
4-5								1	
Transect totals	11	1	.020	2	.040	56	.140	44	

	Number	Wet weight (gms.)
Total Chironomidae	58	.180

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.016	.144
Milligrams protein per square foot	.859	7.36

Table 43. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, May 18, 1952. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
5-1	9		.014			21	.050	10	
5-2	8		.014	1	.060	28	.050	19	1 Ceratopogonidae
5-3	2		.003	1	.040	16	.030	25	
5-4	4		.007	2	.025	33	.070	9	
5-5	*								
Transect totals **	23		.038	4	.125	98	.200	63	

	Number	Wet weight (gms.)
Total Chironomidae	102	.325

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.038	.325
Milligrams protein per square foot	2.04	16.6

* Missing data.

** Given on the basis of four samples.

Table 44. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, May 18, 1952. Transect 8.

Sample number	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
8-1	5		.010	4	.090	8	.010		
8-2	3		.004	1	.040	5	.005		
8-3	6		.006	2	.080	6	.010	5	
8-4	10		.014	3	.050	11	.010	3	
8-5	12		.020	1	.030	11	.010	2	
Transect totals	36		.054	11	.290	41	.045	10	

	Number	Wet weight (gms.)
Total Chironomidae	52	.335

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.043	.268
Milligrams protein per square foot	2.31	13.7

Table 45. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, May 18, 1952. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1	41		.062			16	.025		
9-2	7		.010			15	.025	11	1 Ceratopogonidae
9-3	17		.026			5	.005	5	
9-4	15		.022	1	.030	9	.010	5	
9-5	8		.015	1	.005	8	.020	11	
Transect totals	88		.135	2	.035	53	.085	32	

	Number	Wet weight (gms.)
Total Chironomidae	55	.120

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.108	.096
Milligrams protein per square foot	5.80	4.91

Table 46. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, June 27, 1952. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1A	1							2	
4-1B		1						3	
4-2A	2		.006	1	.040	8	.010	2	
4-2B	1		.002			10	.020		
4-3A									
4-3B	1							4	
4-4A		1				10	.020		
4-4B	4		.009	1	.030	10	.020	3	
4-5A									1 Ceratopogonidae
4-5B									
Transect totals	9	2						14	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.017	.140
Milligrams protein per square foot	1.13	7.16

Table 47. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, June 28, 1952. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
5-1A	2	1						3	
5-1B	1	1						5	
5-2A	1	1	.001	1	.040	9	.025	7	
5-2B	1		.002	2	.025	15	.050	13	
5-3A		1						9	
5-3B	2							3	1 unknown
5-4A				2	.090	22	.040	13	1 Ceratopogonidae & 1 adult Diptera
5-4B	2		.003	2	.070	20	.050	14	
5-5A								3	
5-5B	3							9	
Transect totals	12	4						79	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.006	.440
Milligrams protein per square foot	.397	22.5

Table 48. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, June 30, 1952. Transect 8.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
8-1A	7	2						1	
8-1B	2								
8-2A	10		.020			14	.020	1	
8-2B	7		.020	2	.060	14	.050	1	
8-3A	6	1							
8-3B	3								
8-4A	6	1	.013	3	.070	22	.040		
8-4B	3	1	.005			14	.030		
8-5A	4								
8-5B	2	2						2	
Transect totals	50	7						5	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.058	.270
Milligrams protein per square foot	3.84	13.8

Table 49. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, June 26, 1952. Transect 9.

Sample number	Chaoborus: Larvae	Chaoborus: Pupae	Chaoborus: Wet weight (gms.)	Chironomidae, Chironominae: Number	Chironomidae, Chironominae: Wet weight (gms.)	Chironomidae, Other Chironomidae: Number	Chironomidae, Other Chironomidae: Wet weight (gms.)	Oligochaeta: Number	Miscellaneous: Number
9-1A	4								
9-1B	3							2	
9-2A				13	.270	10	.025	1	
9-2B	5	2	.009	10	.210	8	.020	2	1 Ceratopogonidae
9-3A	5	2						3	
9-3B	3	1						1	
9-4A	7		.011	6	.150	18	.040	2	1 Ceratopogonidae
9-4B	6	2	.010	4	.120	12	.025		
9-5A	3							3	
9-5B	1	3							1 Ceratopogonidae
Transect totals	37	10						14	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.030	.860
Milligrams protein per square foot	1.99	43.95

Table 50. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 22, 1952. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1A									
4-1B								1	
4-2A	1		.002			2	.004		
4-2B						3	.006		
4-3A									
4-3B								3	
4-4A	1		.002	1	.040	2	.004		
4-4B	3		.007			3	.006		
4-5A									
4-5B								2	
Transect totals	5							6	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.011	.060
Milligrams protein per square foot	.660	3.07

Table 51. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 22, 1952. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
5-1A	1							1	
5-1B								1	
5-2A	1		.002					1	
5-2B	2		.006			1	.001	2	
5-3A	2	1						1	
5-3B	1							1	
5-4A						1	.001		
5-4B	1		.002			1	.001	3	
5-5A									
5-5B								1	
Transect totals	8	1						11	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.010	.003
Milligrams protein per square foot	.600	.153

Table 52. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 26, 1952. Transect 8.

Sample number	Chaoborus: Larvae	Chaoborus: Pupae	Chaoborus: Wet weight (gms.)	Chironomidae: Chironominae: Number	Chironomidae: Chironominae: Wet weight (gms.)	Chironomidae: Other Chironomidae: Number	Chironomidae: Other Chironomidae: Wet weight (gms.)	Oligochaeta: Number	Miscellaneous: Number
8-1A	2								
8-1B	1								
8-2A	2		.004	2	.040	1	.002		
8-2B						3	.006		
8-3A	2								
8-3B	2							1	
8-4A				1	.020	2	.004	7	
8-4B						1	.003		
8-5A								1	
8-5B									
Transect totals	9							9	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.004	.075
Milligrams protein per square foot	.240	3.83

Table 53. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 21, 1952. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1A	4	1						4	
9-1B	7	1						2	
9-2A	7		.015	1	.030	8	.010	2	
9-2B	6	3	.011					4	
9-3A	5	1						12	
9-3B	6	2						15	
9-4A	7		.015	1	.030	12	.010	2	1 Ceratopo-gonidae
9-4B	5		.010	3	.060	1	.001		
9-5A	9	1						2	
9-5B	5							4	
Transect totals	61	9						47	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.051	.140
Milligrams protein per square foot	3.06	7.16

Table 54. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, September 25, 1952. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscel- laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1A	2		*	*	*	*	*	2	
4-1B	3		*	*	*	*	*		
4-2A	2		.003			3	.012	2	
4-2B	6		.012			1	.004	2	
4-3A	7		*	*	*	*	*		
4-3B	6		*	*	*	*	*		
4-4A	2		.003			2	.006	1	
4-4B	3		.006			5	.014	2	
4-5A	2		*	*	*	*	*		
4-5B	2		*	*	*	*	*	3	
Transect totals	35		*	*	*	*	*	12	

	Chaoborus	Chironomidae
Grams wet weight per square foot	.024	.036
Milligrams protein per square foot	1.14	1.84

* Not calculated.

Table 55. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, September 26, 1952. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
5-1A	11		*	*	*	*	*		
5-1B	7		*	*	*	*	*	2	
5-2A	8		.013					1	
5-2B	5		.006			3	.001		
5-3A	5		*	*	*	*	*	1	
5-3B	7		*	*	*	*	*	1	
5-4A	7		.011			2	.001	1	
5-4B	14		.022						
5-5A	8		*	*	*	*	*	4	
5-5B	12		*	*	*	*	*	1	
Sample totals	84		*	*	*	*	*	11	

	Chaoborus	Chironomidae
Grams wet weight per square foot	.052	.002
Milligrams protein per square foot	2.47	.102

* Not calculated.

Table 56. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, September 26, 1952. Transect 8.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
8-1A	6							1	
8-1B	4								
8-2A	15		.024						
8-2B	16		.026						
8-3A	9							1	
8-3B	15								
8-4A	6		.010	1	.010	1	.001		
8-4B	5		.009			1	.001		
8-5A	22								
8-5B	11								
Transect totals	109							2	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.069	.011
Milligrams protein per square foot	3.28	.562

Table 57. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, September 26, 1952. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1A	50		*	*	*	*	*	11	
9-1B	47		*	*	*	*	*	5	
9-2A	40		.062					3	
9-2B	49		.087			2	.004		
9-3A	62		*	*	*	*	*		
9-3B	58		*	*	*	*	*		
9-4A	67		.117			1	.002	1	
9-4B	36		.062			1	.001		
9-5A	52		*	*	*	*	*		
9-5B	21		*	*	*	*	*		
Transect totals	482		*	*	*	*	*	20	

	Chaoborus	Chironomidae
Grams wet weight per square foot	.328	.007
Milligrams protein per square foot	15.59	.307

* Not calculated.

Table 58. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, November 13, 1952. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1A	4							4	
4-1B	5							12	1 Amphipoda
4-2A	5		.008			1	.002	1	
4-2B	1		.002					1	
4-3A	4							3	
4-3B	2							1	
4-4A	4		.006	1	.002	13	.010	6	
4-4B	3		.005	1	.001	3	.006	2	
4-5A	1							1	
4-5B	6							6	
Transect totals	35							36	

	Chaoborus	Chironomidae
Grams wet weight per square foot	.021	.020
Milligrams protein per square foot	1.26	1.02

Table 59. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, November 13, 1952. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscel- laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
5-1A	6		*	*	*	*	*	5	
5-1B	3		*	*	*	*	*	2	
5-2A	14		.022			2	.003	3	
5-2B	12		.018			4	.007	2	
5-3A	13		*	*	*	*	*	2	
5-3B	7		*	*	*	*	*	1	
5-4A	17		.029			9	.010	2	
5-4B	4		.008			4	.005	1	
5-5A	9		*	*	*	*	*	7	
5-5B	6		*	*	*	*	*		
Transect totals	91		*	*	*	*	*	25	

	Chaoborus	Chironomidae
Grams wet weight per square foot	.077	.025
Milligrams protein per square foot	4.60	1.28

* Not calculated.

Table 60. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, November 13, 1952. Transect 8.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
8-1A	8							1	
8-1B	5								
8-2A	10		.020	2	.060	2	.003		
8-2B	18		.032	1	.040	3	.004	2	
8-3A	11							2	
8-3B	6								
8-4A	16*		.028*			4	.004*		
8-4B	21		.034			2	.002	3	
8-5A	25							1	
8-5B	19							1	
Transect totals	139							10	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.114	.113
Milligrams protein per square foot	6.82	5.78

* Missing data calculated.

Table 61. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, November 12, 1952. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1A	50		*	*	*	*	*		
9-1B	59		*	*	*	*	*		
9-2A	61		.104			2	.003	6	
9-2B	39		.067			5	.007	9	
9-3A	31		*	*	*	*	*	7	
9-3B	31		*	*	*	*	*	4	
9-4A	41		.075			3	.005		
9-4B	33		.057	3	.020	2	.005	4	
9-5A	47		*	*	*	*	*	2	
9-5B	28		*	*	*	*	*	2	
Transect totals	420		*	*	*	*	*	34	

	Chaoborus	Chironomidae
Grams wet weight per square foot	.303	.040
Milligrams protein per square foot	18.1	2.04

* Not calculated.

Table 62 . Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, January 27, 1953. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1A	2		.004	2	.040	3	.001	3	
4-1B	3		.004	1	.020	6	.025	14	
4-2A	5		.008			5	.015	2	
4-2B	2		.003			5	.010	6	
4-3A	5		.008			6	.025	15	
4-3B	1		.002			4	.010	4	
4-4A	9		.017	1	.020	2	.005	2	1 Amphipoda
4-4B				1	.020	2	.005	2	
4-5A	2		.003			4	.010	7	
4-5B	4		.006	5		7	.020	4	
Transect totals	33		.055	5	.100	44	.126	59	

	Number	Wet weight (gms.)
Total Chironomidae	49	.226

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.022	.0904
Milligrams protein per square foot	1.21	4.62

Table 63. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, January 28, 1953. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
5-1A	3		.006	3	.010	8	.012	4	
5-1B	10		.018	1	.007	17	.020	14	1 Mayfly nymph *
5-2A	10		.018			3	.003	2	1 bird shot
5-2B	1		.002			4	.010	2	
5-3A	3		.007			5	.015		1 Amphipoda
5-3B	3		.005	2	.075	5	.020	1	4 Amphipoda
5-4A	5		.009	3	.025	11	.030	6	
5-4B	10		.018	1	.002	9	.015	2	1 bird shot
5-5A	3		.006	1	.006	1	.004	2	
5-5B	2		.003			14	.040	4	
Transect totals	50		.092	11	.125	77	.169	37	* Hexagenia limbata

	Number	Wet weight (gms.)
Total Chironomidae	88	.294

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0368	.1176
Milligrams protein per square foot	2.02	6.01

Table 64. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, January 26, 1953. Transect 8.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
8-1A	3		.006			1	.001		
8-1B	5		.009			8	.010	2	
8-2A	16		.031	3	.025	9	.020		
8-2B	9		.018	2	.040	1	.001		
8-3A	1		.002	1	.040	3	.005	1	
8-3B	4		.007			4	.006	2	
8-4A	2		.005			10	.015		
8-4B	3		.007			3	.005		
8-5A	4		.008			4	.005		1 Amphipoda
8-5B	7		.015	1	.020	4	.010		
Transect totals	54		.108	7	.125	47	.078	5	

	Number	Wet weight (gms.)
Total Chironomidae	54	.203

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0432	.0812
Milligrams protein per square foot	2.37	4.15

Table 65. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, January 25, 1953. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample numbers	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1A	30		.051	1	.005	1	.002	14	1 Ceratopogonidae
9-1B	25		.045	12	.060	4	.005	7	
9-2A	15		.032			5	.010	2	
9-2B	24		.040			9	.010	3	
9-3A	47		.087			6	.010	4	
9-3B	34		.058			3	.020	5	
9-4A	38		.065	9	.040	7	.020		
9-4B	44		.075	11	.090	8	.025		
9-5A	38		.064	2	.010	8	.020		
9-5B	7		.013			4	.015	1	
Transect totals	302		.530	35	.205	55	.137	36	

	Number	Wet weight (gms.)
Total Chironomidae	90	.342

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.212	.1368
Milligrams protein per square foot	11.6	6.99

Table 66. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, March 25, 1953. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1A	8		.015			6	.020	1	
4-1B	4		.007	2	.010	1	.003	2	
4-2A	11		.017			12	.030	8	
4-2B	5		.008			7	.022	2	
4-3A	2		.004			7	.020	4	1 Bug *
4-3B	2		.003			4	.030	1	
4-4A	2		.005	9	.090	10	.025	8	
4-4B	1		.002	2	.020	6	.010		
4-5A	3		.006	1	.010	11	.020	5	
4-5B	2		.005	2	.030	7	.015	5	
Transect totals	40		.072	16	.160	71	.195	36	* Terrestrial Hemiptera

	Number	Wet weight (gms.)
Total Chironomidae	87	.355

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0288	.142
Milligrams protein per square foot	1.58	7.26

Table 67. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, March 25-26, 1953. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
5-1A	13		.022			10	.030	1	
5-1B	6		.013			2	.003		
5-2A	8		.015	1	.010	10	.025	1	
5-2B	1		.002	1	.010	1	.002		
5-3A	6		.012	1	.020	1	.001	2	
5-3B	4		.008			5	.007	1	
5-4A	5		.011	1	.004	9	.020	8	
5-4B	11		.026			3	.005	3	1 Caddis *
5-5A	5		.010	1	.006	2	.010	1	1 bird shot
5-5B	2		.005			2	.003	1	
Transect totals	61		.124	5	.050	45	.106	18	* *Oecetis inconspicua* (Walker)

	Number	Wet weight (gms.)
Total Chironomidae	50	.156

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0496	.0624
Milligrams protein per square foot	2.72	3.19

Table 68. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, March 26, 1953. Transect 8.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
8-1A	4		.009			5	.020	1	
8-1B	5		.011	2	.080	1	.005	1	
8-2A	6		.012	2	.030	2	.010	1	
8-2B	5		.010	2	.020	1	.002		
8-3A	9		.017	3	.070	10	.030	1	
8-3B	6		.012	5	.040	6	.060	3	
8-4A	2		.005	1	.060	1	.002		
8-4B	7		.014			4	.010		
8-5A	10		.022	1	.010	1	.003	1	
8-5B	11		.022			8	.015		
Transect totals	65		.134	16	.310	39	.157	8	

	Number	Wet weight (gms.)
Total Chironomidae	55	.467

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.054	.187
Milligrams protein per square foot	2.94	9.56

Table 69. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, March 25, 1953. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1A	26		.052	1	.002	3	.010	4	
9-1B	51		.099			2	.007	9	
9-2A	29		.057			3	.010	4	
9-2B	37		.078	2	.020	1	.003	7	
9-3A	43		.086	10	.080	3	.005	8	
9-3B	45		.087			3	.009	4	
9-4A	43		.086			2	.005	7	
9-4B	36		.068			6	.010	3	
9-5A	38		.071	3	.060	2	.021	1	
9-5B	24		.045	2	.060	4	.010		
Transect totals	372		.729	18	.222	29	.090	47	

	Number	Wet weight (gms.)
Total Chironomidae	47	.312

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.2916	.125
Milligrams protein per square foot	15.99	6.39

Table 70. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 9, 1953. Transect 4.

Sample number	Chaoborus: Larvae	Chaoborus: Pupae	Chaoborus: Wet weight (gms.)	Chironominae: Number	Chironominae: Wet weight (gms.)	Other Chironomidae: Number	Other Chironomidae: Wet weight (gms.)	Oligochaeta: Number	Miscellaneous: Number
4-1A				2	.060	21	.050	6	1 Mayfly nymph *
4-1B						10	.020	2	
4-2A						11	.020	3	
4-2B						4	.010		
4-3A	1		.001			19	.030	10	
4-3B						14	.040	8	
4-4A						31	.070	5	
4-4B						8	.020	11	
4-5A				1	.020	12	.030	3	
4-5B				1	.015	32	.060	8	
Transect totals	1		.001	4	.095	162	.350	56	*Hexagenia limbata

	Number	Wet weight (gms.)
Total Chironomidae	166	.445

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0004	.178
Milligrams protein per square foot	.024	9.10

Table 71. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 14, 1953. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
5-1A				1	.005	13	.025	2	
5-1B						14	.040	2	1 bird shot
5-2A						9	.030	9	
5-2B	1		.001			12	.030	2	1 Ephemeroptera *
5-3A				1	.002	12	.020	2	1 Ceratopogonidae
5-3B						12	.040	7	
5-4A				1	.010	14	.030	3	
5-4B						10	.020	7	
5-5A				1	.010	13	.040	3	
5-5B						12	.035	4	
Transect totals	1		.001	4	.027	121	.310	41	* Caenis sp.

	Number	Wet weight (gms.)
Total Chironomidae	125	.337

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0004	.1348
Milligrams protein per square foot	.024	6.89

Table 72. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 22, 1953. Transect 8.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
8-1A	1		.001	1	.060	20	.050	1	
8-1B		1				12	.020	1	
8-2A	2		.001	1	.045	15	.050	5	
8-2B		2		1	.040	12	.020	1	
8-3A						13	.025	3	
8-3B	2		.002			3	.006		
8-4A				1	.040	3	.003		
8-4B	1	1	.002	2	.040	9	.025		
8-5A						8	.030	1	
8-5B						6	.015	3	
Transect totals	6	4	.006	6	.225	101	.244	15	

	Number	Wet weight (gms.)
Total Chironomidae	107	.469

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0024	.1876
Milligrams protein per square foot	0.144	9.59

Table 73 . Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 28, 1953. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1A	11		.021	1	.040	3	.004	3	
9-1B	15		.025			1	.001	1	
9-2A	7	2	.011					4	
9-2B	8	2	.014	1	.040			4	
9-3A	20		.033					4	
9-3B	16	2	.025			5	.005	1	
9-4A	20	1	.028	3	.060	3	.010		
9-4B	16	2	.026			2	.002		
9-5A	22	4	.032			1	.001	1	
9-5B	20	1	.031			1	.001		
Transect totals	155	14	.246	5	.140	16	.024	18	

	Number	Wet weight (gms.)
Total Chironomidae	21	.164

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0984	.0656
Milligrams protein per square foot	5.90	3.35

Table 74. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, August 6, 1953. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1A	2		.003	2	.020	8	.020	1	
4-1B	2		.003	1	.010	28	.040	7	
4-2A	1		.002			13	.030		
4-2B						12	.020	2	
4-3A				1	.001	10	.019	5	1 Ceratopogonidae
4-3B				1	.002	14	.030	2	
4-4A	6		.004			4	.010	7	
4-4B	12		.007	3	.001	15	.030	6	
4-5A	3		.003			17	.030	7	
4-5B	2		.002			17	.040	4	
Transect totals	28		.024	8	.034	138	.269	41	

	Number	Wet weight (gms.)
Total Chironomidae	146	.303

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0096	.1212
Milligrams protein per square foot	.516	6.19

Table 75. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, August 14, 1953. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
5-1A	3		.004	1	.005	13	.020	3	
5-1B	2	1	.002	4	.020	9	.015	4	
5-2A	16		.019	1	.005	13	.015		
5-2B	3		.003			23	.050	14	1 Ceratopogonidae
5-3A	4	2	.004			9	.015		
5-3B	2		.003			6	.005	2	
5-4A	3	1	.004	2	.020	13	.030	2	1 bird shot
5-4B	5		.005			16	.030	1	
5-5A	6		.004	3	.055	8	.017	7	
5-5B	4		.005	1	.015	2	.003	1	
Transect totals	48	4	.053	12	.120	112	.200	34	

	Number	Wet weight (gms.)
Total Chironomidae	124	.320

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0212	.128
Milligrams protein per square foot	1.14	6.54

Table 76 . Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, August 19, 1953. Transect 8.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
8-1A	11	1	.030			17	.050		
8-1B	23	1	.028	1	.010	17	.030		
8-2A	10		.017	1	.010	3	.005	2	
8-2B	20	1	.031			6	.010		
8-3A	2		.003			10	.023	1	
8-3B	16	4	.019			6	.005		
8-4A	5		.006			3	.007		
8-4B	29	3	.032			8	.010		
8-5A	18	4	.020			7	.010		
8-5B	12	2	.018			4	.150		
Transect totals	146	16	.204	2	.020	81	.300	3	

	Number	Wet weight (gms.)
Total Chironomidae	83	.320

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0816	.128
Milligrams protein per square foot	4.39	6.54

Table 77. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, August 28, 1953. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1A	61	1	.060	1	.020	7	.010	4	
9-1B	57	4	.054			8	.005	7	
9-2A	39	3	.036			14	.020	1	
9-2B	66	1	.050			14	.028	6	
9-3A	38	3	.040	2	.010	6	.005	14	
9-3B	42	2	.034			3	.007	6	
9-4A	44	1	.052			4	.010		
9-4B	87	2	.080			1	.002		
9-5A	36	2	.020	1	.010	11	.020	2	
9-5B	37	3	.039			1	.002		
Transect totals	507	22	.465	4	.040	69	.109	40	

	Number	Wet weight (gms.)
Total Chironomidae	73	.149

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.186	.0596
Milligrams protein per square foot	10.0	3.05

Table 78. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, March 20, 1954. Transect N4.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
N4-2A	3		.004			3	.010	4	
N4-2B	5		.008	1	.005	6	.004	24	
N4-4A	9		.013	4	.030	5	.005	13	
N4-4B	2		.002	13	.050	6	.005	19	
Transect totals	19		.027	18	.085	20	.024	60	

	Chaoborus	Chironomidae
Grams wet weight per square	.027	.109
Milligrams protein per square foot	1.48	5.57

Table 79. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, March 20, 1954. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1A	7		.013			2	.002	3	
4-1B	7		.012	7	.025	1	.001	2	
4-2A	12		.018	10	.025	7	.010	16	
4-2B	6		.010			2	.005	1	
4-3A	9		.013	1	.002	5	.007	9	
4-3B	3		.004	7	.030	3	.003	13	
4-4A	5		.008	21	.080	6	.010	6	
4-4B	3		.004	8	.040	6	.005	2	
4-5A	8		.011			14	.025	20	
4-5B	9		.016	1	.010	10	.020	22	
Transect totals	69		.109	55	.212	56	.088	94	

	Number	Wet weight (gms.)
Total Chironomidae	111	.300

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.044	.120
Milligrams protein per square foot	2.39	6.13

Table 80. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, March 21, 1954. Transect N5.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
N5-2A	8		.011			1	.002	5	
N5-2B	5		.006			2	.002	5	
N5-4A	10		.014	8	.070	2	.002	4	
N5-4B	12		.017	2	.010	2	.006	4	
Transect totals	35		.048	10	.080	7	.012	18	

	Chaoborus	Chironomidae
Grams wet weight per square foot	.048	.092
Milligrams protein per square foot	2.63	4.70

Table 81. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, March 21, 1954. Transect 5.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
5-1A	20		.031	2	.002	18	.010	11	1 Hexagenia limbata nymph
5-1B	26		.038	2	.020	10	.020	12	
5-2A	8		.012			4	.010	5	
5-2B	9		.015	1	.005	5	.005	4	
5-3A	3		.005	8	.030	11	.010	7	
5-3B	14		.020	6	.020	11	.020	13	
5-4A	7		.009	1	.010	7	.015	3	
5-4B	2		.003	5	.030	4	.005	5	
5-5A	12		.018	3	.020	5	.005	4	1 Hexagenia limbata nymph
5-5B	8		.014	2	.020	10	.015	2	1 Hexagenia limbata nymph
Transect totals	109		.165	30	.157	85	.115	66	

	Number	Wet weight (gms.)
Total Chironomidae	115	.272

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.066	.109
Milligrams protein per square foot	3.62	5.57

Table 82. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, March 21, 1954. Transect N8.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
N8-2A	33		.058	1	.070	4	.012		
N8-2B	26		.043	2	.030	1	.003	1	
N8-4A	36		.061			10	.015	3	
N8-4B	25		.046	1	.002	4	.012	3	
Transect totals	120		.208	4	.102	19	.042	7	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.208	.144
Milligrams protein per square foot	11.4	7.36

Table 83. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, March 21, 1954. Transect 8.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
8-1A	23		.036	3	.040	3	.008	3	
8-1B	35		.057	1	.010	5	.012	9	
8-2A	52		.079	2	.010	9	.020	2	
8-2B	37		.057	1	.030	7	.002	8	
8-3A	22		.035	1	.040	3	.001	5	
8-3B	17		.028			7	.020		
8-4A	34		.056	1	.050	10	.020	6	
8-4B	23		.036	1	.040	3	.005	5	
8-5A	12		.019	10	.070	5	.017	3	1 large crayfish (Cambarinae)
8-5B	3		.006	6	.060	1	.003		
Transect totals	258		.409	26	.350	53	.108	44	

	Number	Wet weight (gms.)
Total Chironomidae	79	.458

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.164	.183
Milligrams protein per square foot	8.99	9.35

Table 84. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, March 21, 1954. Transect N9.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
N9-2A	27		.040	3	.080	7	.010	2	
N9-2B	30		.047	2	.015	8	.020	4	
N9-4A	24		.037	3	.095	8	.010	7	
N9-4B	50		.078			6	.010	13	
Transect totals	131		.202	8	.190	29	.050	26	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.202	.240
Milligrams protein per square foot	11.08	12.27

Table 85. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, March 21, 1954. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1A	40		.059	2	.020	4	.010	7	
9-1B	56		.092	6	.030	7	.005	3	
9-2A	68		.104			3	.001	5	
9-2B	42		.066	2	.070	12	.010	6	
9-3A	43		.069	1	.010	13	.010	6	
9-3B	59		.094	1	.025	11	.020	16	1 adult Diptera
9-4A	152		.302	1	.040	8	.004		
9-4B	117		.188	1	.010	8	.010		
9-5A	49		.074	1	.040	11	.005		
9-5B	93		.153	1	.040	11	.009	1	
Transect totals	719		1.201	16	.285	88	.084	44	

	Number	Wet weight (gms.)
Total Chironomidae	104	.369

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.480	.148
Milligrams protein per square foot	26.3	7.56

Table 86 . Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 2, 1954. Transect N4.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
N4-2A	0		.000	1	.02	4	.005	11	
N4-2B	3		.005	1	.075	11	.030	6	1 adult Diptera
N4-4A	2		.002			3	.003	10	1 Zygoptera nymph
N4-4B	2		.003			6	.005	15	
Transect totals	7		.010	2	.095	24	.043	42	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.010	.138
Milligrams protein per square foot	.600	7.05

Table 87. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 2, 1954. Transect 4.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
4-1A	3		*	*	*	*	*	6	1 Ceratopogonidae larvae
4-1B	1		*	*	*	*	*	3	
4-2A	2		.007			1	.001	5	
4-2B	1		.002			1	.001	1	
4-3A	1		*	*	*	*	*	13	
4-3B	3		*	*	*	*	*	3	
4-4A						2	.002	10	
4-4B		1				4	.003	15	
4-5A	6		*	*	*	*	*	7	
4-5B	5		*	*	*	*	*	12	1 Coleoptera larvae
Transect totals	22	1	*	*	*	*	*	75	

	Chaoborus	Chironomidae
Grams wet weight per square foot	.009	.007
Milligrams protein per square foot	.540	.358

* Not calculated.

Table 88. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 22, 1954. Transect N5.

	Chaoborus			Chironomidae				Oligochaeta	Miscel- laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
N5-2 A	14	1	.016						
N5-2 B	26	2	.026	1	.030	2	.005	1	
N5-4 A	11		.012			2	.005	3	
N5-4 B	7	1	.008			2	.005	4	
Transect totals	58	4	.062	1	.030	6	.015	8	

	Chaoborus	Chironomidae
Grams wet weight per square foot	.062	.045
Milligrams protein per square foot	3.72	2.30

Table 89. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 22, 1954. Transect 5.

Sample number	Chaoborus Larvae	Chaoborus Pupae	Chaoborus Wet weight (gms.)	Chironomidae Number	Chironomidae Wet weight (gms.)	Chironomidae Number	Chironomidae Wet weight (gms.)	Oligochaeta Number	Miscellaneous Number
5-1A	11							3	
5-1B	8	1						1	
5-2A	7	1	.011			7	.015	1	
5-2B	17		.023					3	1 bird shot
5-3A	3							3	
5-3B	3							1	
5-4A	7		.009			6	.020		
5-4B	9		.005			4	.010	6	
5-5A	3							1	
5-5B								4	1 bird shot
Transect totals	68	2						23	2 bird shot

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.048	.045
Milligrams protein per square foot	2.88	2.30

Table 90 . Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 29, 1954. Transect N8.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
N8-2A	64	8	.072						
N8-2B	43	2	.052			3	.010		
N8-4A	72	3	.079			3	.010	1	
N8-4B	20	2	.024			1	.001	1	
Transect totals	199	15	.227			7	.021	2	

	Chaoborus	Chironomidae
Grams wet weight per square foot	.227	.021
Milligrams protein per square foot	13.6	1.07

Table 91. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, July 30, 1954. Transect 8.

	Chaoborus			Chironomidae				Oligochaeta	Miscel-laneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
8-1A	34	3							1 adult Diptera
8-1B	7	1							
8-2A	9		.013			2	.0025		
8-2B	24		.032			6	.0075		
8-3A	15								
8-3B	20	2							
8-4A	44	1	.063			2	.004		
8-4B	38	1	.053			3	.006		
8-5A	18							1	
8-5B	27	4							
Transect totals	236	12						1	1 adult Diptera

	Chaoborus	Chironomidae
Grams wet weight per square foot	.161	.020
Milligrams protein per square foot	9.66	1.02

Table 92. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, August 13, 1954. Transect N9.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
N9-2A	16		.016			21	.020		
N9-2B	18		.017			9	.016		
N9-4A	6		.009	1	.015	2	.004	1	
N9-4B	6		.009	1	.015	3	.006		
Transect totals	46		.051	2	.030	35	.046	1	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.051	.076
Milligrams protein per square foot	2.74	3.88

Table 93. Numbers, wet weights and crude protein content of bottom fauna in quarter square-foot Ekman samples, North Twin Lake, August 21, 1954. Transect 9.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
9-1A	8	1						2	
9-1B	14							1	
9-2A	12		.017			18	.030	4	
9-2B	13	1	.011	3	.030	24	.030	1	
9-3A	12	1						1	
9-3B								2	
9-4A	14	1	.017			18	.025		
9-4B	3	1	.004			18	.025		
9-5A	39	3							
9-5B	11	3							
Transect totals	134	11						11	

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.049	.140
Milligrams protein per square foot	2.63	7.16

Table 94. Numbers, wet weights and crude protein content of bottom fauna in one square foot Ekman samples, North Twin Lake, July 9, 1954. Transect FN4.

Sample numbers	Chaoborus Larvae	Chaoborus Pupae	Chaoborus Wet weight (gms.)	Chironomidae: Chironominae Number	Chironomidae: Chironominae Wet weight (gms.)	Chironomidae: Other Chironomidae Number	Chironomidae: Other Chironomidae Wet weight (gms.)	Oligochaeta Number	Miscellaneous Number
FN4-2A	13	2	.015	4	.110	63	.090	15	1 Mayfly nymph *
FN4-2B	15	3	.021	1	.030	35	.050	17	
FN4-4A	12	2	.016	3	.050	38	.050	42	
FN4-4B	16	2	.024	1	.030	23	.040	43	1 Ceratopogonidae larvae
Transect totals	56	9	.076	9	.220	159	.230	117	* <u>Hexagenia limbata</u> (Serville)

	Number	Wet weight (gms.)
Total Chironomidae	168	.450

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.019	.112
Milligrams protein per square foot	1.14	5.75

Table 95 . Numbers, wet weights and crude protein content of bottom fauna in one square foot Ekman samples, North Twin Lake, July 9, 1954. Transect F4.

Sample number	Chaoborus: Larvae	Chaoborus: Pupae	Chaoborus: Wet weight (gms.)	Chironomidae, Chironominae: Number	Chironomidae, Chironominae: Wet weight (gms.)	Chironomidae, Other Chironomidae: Number	Chironomidae, Other Chironomidae: Wet weight (gms.)	Oligochaeta: Number	Miscel-laneous: Number
F4-2A	13		.019	4	.120	14	.010	36	
F4-2B	5		.007	1	.030	26	.040	18	
F4-4A	8	1	.009	1	.025	50	.065	23	
F4-4B	12	2	.017			19	.030	10	
Transect totals	38	3	.052	6	.175	109	.145	87	

	Number	Wet weight (gms.)
Total Chironomidae	115	.320

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.013	.080
Milligrams protein per square foot	.780	4.09

Table 96. Numbers, wet weights and crude protein content of bottom fauna in one square foot Ekman samples, North Twin Lake, July 24, 1954. Transect FN5.

Sample number	Chaoborus: Larvae	Chaoborus: Pupae	Chaoborus: Wet weight (gms.)	Chironomidae, Chironominae: Number	Chironomidae, Chironominae: Wet weight (gms.)	Chironomidae, Other Chironomidae: Number	Chironomidae, Other Chironomidae: Wet weight (gms.)	Oligochaeta: Number	Miscellaneous: Number
FN5-2A	110	4	.103	4	.095	27	.030	34	
FN5-2B	74	4	.086			9	.015	34	
FN5-4A	66	11	.069	2	.06	11	.005	20	
FN5-4B	30		.036			2	.005	35	
Transect totals	280	19	.294	6	.155	49	.055	123	

	Number	Wet weight (gms.)
Total Chironomidae	55	.210

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0735	.0525
Milligrams protein per square foot	4.41	2.68

Table 97. Numbers, wet weights and crude protein content of bottom fauna in one square foot Ekman samples, North Twin Lake, July 24, 1954. Transect F5.

Sample number	Chaoborus: Larvae	Chaoborus: Pupae	Chaoborus: Wet weight (gms.)	Chironomidae – Chironominae: Number	Chironomidae – Chironominae: Wet weight (gms.)	Chironomidae – Other Chironomidae: Number	Chironomidae – Other Chironomidae: Wet weight (gms.)	Oligochaeta: Number	Miscellaneous: Number
F5-2A	34	7	.039	3	.140	7	.020	17	
F5-2B	33	3	.035	1	.040	3	.002	15	
F5-4A	82		.095			11	.030	13	
F5-4B	57	5	.060	1	.035	10	.010	6	
Transect totals	206	15	.229	5	.215	31	.062	51	

	Number	Wet weight (gms.)
Total Chironomidae	36	.277

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0572	.0692
Milligrams protein per square foot	3.44	3.54

Table 98. Numbers, wet weights and crude protein content of bottom fauna in one square foot Ekman samples, North Twin Lake, August 5, 1954. Transect FN8.

Sample number	Chaoborus Larvae	Chaoborus Pupae	Chaoborus Wet weight (gms.)	Chironomidae: Chironominae Number	Chironomidae: Chironominae Wet weight (gms.)	Chironomidae: Other Chironomidae Number	Chironomidae: Other Chironomidae Wet weight (gms.)	Oligochaeta Number	Miscellaneous Number
FN8-2A	19	2	.029	4	.150	1	.001		
FN8-2B	34	6	.043	4	.100	12	.005	4	
FN8-4A	72	4	.092			19	.030	1	
FN8-4B	53	4	.003			10	.025		
Transect totals	178	16	.227	8	.310	42	.061	5	

	Number	Wet weight (gms.)
Total Chironomidae	50	.371

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0568	.0928
Milligrams protein per square foot	3.05	4.74

Table 99. Numbers, wet weights and crude protein content of bottom fauna in one square-foot Ekman samples, North Twin Lake, August 6, 1954. Transect F8.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
F8-2A	46	6	.062	2	.050	23	.030	7	
F8-2B	20	2	.024			4	.008	3	
F8-4A	44	4	.060	3	.110	15	.032	1	
F8-4B	44	7	.050			19	.035		1 ceratopogonidae larvae
Transect totals	154	19	.196	5	.160	61	.105	11	

	Number	Wet weight (grams)
Total Chironomidae	66	.265

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.049	.0663
Milligrams protein per square foot	2.63	3.39

Table 100. Numbers, wet weights and crude protein content of bottom fauna in one square foot Ekman samples, North Twin Lake, August 13, 1954. Transect FN9.

	Chaoborus			Chironomidae				Oligochaeta	Miscellaneous
				Chironominae		Other Chironomidae			
Sample number	Larvae	Pupae	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Wet weight (gms.)	Number	Number
FN9-2A	45	3	.054	4	.120	28	.040	3	
FN9-2B	52	1	.064	5	.195	43	.070	17	bird shot
FN9-4A	45		.059	2	.080	23	.020	1	
FN9-4B	37	1	.051	1	.040	12	.010	2	
Transect totals	179	5	.228	12	.435	106	.140	23	

	Number	Wet weight (gms.)
Total Chironomidae	118	.575

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.057	.144
Milligrams protein per square foot	3.06	7.36

Table 101. Numbers, wet weights and crude protein content of bottom fauna in one square foot Ekman samples, North Twin Lake, August 13, 1954. Transect F9.

Sample number	Chaoborus Larvae	Chaoborus Pupae	Chaoborus Wet weight (gms.)	Chironomidae: Chironominae Number	Chironomidae: Chironominae Wet weight (gms.)	Chironomidae: Other Chironomidae Number	Chironomidae: Other Chironomidae Wet weight (gms.)	Oligochaeta Number	Miscellaneous Number
F9-2A	37		.037	2	.050	36	.040	2	
F9-2B	21	2	.019	3	.050	40	.060	3	
F9-4A	44	4	.055	3	.003	82	.075		
F9-4B	36		.038	1	.040	31	.060		
Transect totals	138	6	.149	9	.143	189	.235	5	

	Number	Wet weight (gms.)
Total Chironomidae	198	.378

	Chaoborus	Total Chironomidae
Grams wet weight per square foot	.0372	.0945
Milligrams protein per square foot	2.00	4.83